MILITARY HANDBOOKS FOR REGIMENTAL OFFICERS

VOL. I.

MILITARY SKETCHING AND RECONNAISSANCE

MILITARY HANDBOOKS

FOR

OFFICERS AND NON-COMMISSIONED OFFICERS

EDITED BY

COL. C. B. BRACKENBURY, R.A.

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PREFACE

TO

THE FOURTH EDITION.

THE KINDLY RECOGNITION of critics and the practical fact that three editions have been absorbed prove that this book has been found useful.

Since it was originally published a War Office Committee has investigated the whole subject and made some considerable changes in the English system of Military Sketching. This edition has been thoroughly revised by the authors and embodies the changes and additions which have been made. It will, therefore, be found a safe guide to students who have, indeed, at present, no other manual of instruction which is not behind the time.

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THE FIRST EDITION.

NOT many years ago the officers of the English army might be roughly divided into two classes—the scientific and the non-scientific. The former were deeply versed in mathematics and physical sciences, capable of making accurate maps and of designing or attacking a permanent fortress. They had, however, no knowledge of tactics, except such as had come from their own voluntary studies. On the other hand, officers of the non-scientific class were entirely deficient in knowledge of science, incapable for the most part of even reading a military map, and uninformed on the subject of practical tactics, which was, strangely, regarded as a 'theoretical' study, and therefore condemned.

Thus it comes about that books intended to instruct officers in 'Military Sketching' are, as a rule, suitable rather for surveyors and map-makers than for practical sketches in the field, and contain little or no information

on the art of 'reconnaissance of ground,' which should go hand in hand with military sketching. Similarly a whole library of books might be found to tell by what great fault the Prussians lost the battle of Kolin, or by what wisdom won that of Königgrätz; but there was no work in existence explaining to an English lieutenant how he should lead his handful of men to the best advantage, or even to a colonel how to dispose his battalion so as to deserve success, if not to command it. Officers who were desirous of learning just so much of the military art as is requisite to complete their practical efficiency in the field, without entering deeply into studies which, however valuable, are not necessary except for a few, have had little assistance towards self-education.

It has, however, lately been understood that, on the one hand, a knowledge of drill and interior economy of regiments is insufficient to enable an officer to fulfil his whole duty to his Sovereign and his country in the field; while, on the other hand, a deep knowledge of permanent fortification, the scientific part of artillery, accurate surveying, and the tactics of divisions or armies, are only necessary for a limited number of officers, specially trained.

Strongly impressed by the lack of really elementary books, the Editor appealed to certain garrison instructors to assist him in supplying the want which was felt, not only by students but by the instructors themselves. It is needless to say that any call for special work, when the good purpose of it is clear, always meets with hearty

acquiescence in the English army. By far the greater part of the labour has fallen upon the officers who consented to undertake the task. To them is the chief credit due, and the Editor trusts that their work may receive the recognition which it deserves.

It is to be hoped that the Handbooks, of which this is the first, may prove useful to the Militia and Volunteers as well as to the Regular Army. The Editor can promise them that if they will patiently work through this volume, and one which will shortly follow, containing those detals of elementary tactics which, while of the greatest value, are not to be found in ordinary books on the subject, they will acquire almost a new sense. They will see features of country with a military eye, just as a painter sees them with an artist's eye, and will gain a new and peculiar pleasure as incomprehensible by the outer world as that of the artist, who sees—not dull fields—but lovely pictures in the flattest series of meadows.

In view of future editions, the Editor will feel much indebted for any criticisms or suggestions which may be sent to him.

C. B. BRACKENBURY.

WOODLANDS,
YORK TOWN,
FARNBORO' STATION.

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PART I.

MILITARY SKETCHING.

SECTION I.

DEFINITION AND OBJECT OF MILITARY SKETCHING.

A 'MILITARY SKETCH' is a map or plan of ground, made expressly with a view to give such information as is required for military purposes.

Marches, battles, and other operations of war, cannot be safely planned nor executed without knowledge of the ground on which they are to take place. Ordinary maps of the country, though most useful, only supply this need in part. They are usually on too small a scale to show the necessary details, and, not having been made for military purposes, may omit essential military features. Moreover, new roads may have been made, and other changes taken place since they were published.

Plans of the ground must therefore be made, and hence it is essential that an officer should be capable of making a military sketch. The object of Part I. of the present manual is to assist officers who are under instruction, and to enable those who have not the opportunity of being instructed, to master the mechanical part of military sketching. Its practical application to the purposes of war will form the subject of Part II.

The processes employed in military sketching are essentially the same as those used in ordinary surveying; but the means employed being less perfect, and the time available

being always limited, the same minute accuracy is not attainable. Nor is it required. Details of no military importance are omitted, distances and dimensions often judged instead of being measured, and time economised in various other ways which experience will suggest; care being, however, taken to preserve such correctness in essentials, that the sketch shall be practically serviceable for the purpose it is intended to fulfil.

SECTION II.

INSTRUMENTS USED.

The main points to be considered in the choice of instruments for military sketching are simplicity and portability. Those generally used are the Prismatic Compass and six-inch Protractor, which fulfil both conditions, and are sufficient for all that has to be done; nothing being necessary beyond the means of measuring angles and distances on the ground, and of laying them down on paper, or 'plotting' them as it is called.

The Prismatic Compass.—The reader should have a compass in his hand while studying the following description.

The Prismatic Compass is founded on the well-known property of the magnetic needle; viz. that, when balanced on its centre, and allowed to move round freely, it will come to rest pointing nearly due north.

The construction of the instrument is as follows:

A shallow circular metal box has a short upright pin fixed in the centre of its bottom. On this pin is balanced a magnetic needle. To one side of the rim of the box is fixed a sight vane, with a horse-hair down its centre, and to the opposite side a glass prism, with a slit above it, through which the horse-hair can be seen. The vane and prism are so placed, that a line from the middle of the slit to the horse-hair would pass exactly over the centre of the circle, and both are made to turn down on a hinge, so as to allow the compass to be put into a leather case. The magnetic needle

is fixed to a circular card (or sometimes a metal ring), which it carries with it when it moves round on the point of the upright pin. To prevent the point of the pin from being blunted by the constant friction of the needle turning on it, a small lever is arranged, so that, when the sight vane is turned down, it presses on one end of it, and causes the other end to lift the needle off its bearing. In the outer rim of the box, under the sight vane, is a small knob, which, being pressed, forces a spring against the edge of the card, the use of this being to check the swinging to and fro, which often takes place before the card settles into its proper position. A glass is fitted into the rim of the box to protect the card, and the whole is protected by a metal cover. The edge of the card is divided into degrees, which are read from 0° to 360° round to the right. (Plate I., *fig.* 1.)

To use the compass (which is sometimes put on a tripod stand, but more usually held in the hand), the prism and sight vane are turned up, the eye placed at the slit, and the horse-hair aligned on the object which is to be observed. Care must be taken to hold the compass level, so that the card may swing freely, for if tilted up, so that the edge of the card touches the glass, the needle will be checked, and unable to move round to its proper position. If the card swing violently to and fro, the spring may be used to check it, the pressure being applied when the card is at about the middle of its swing. When the card has settled, the number of the degree which appears * to be cut by the hair, is read. If there is any difficulty in seeing the numbers, the prism may be moved up, by means of the sliding-bar to which it is fixed, till a focus to suit the eye is found.

The number thus read is the 'magnetic bearing' of the object observed; that is, it is the number of degrees in the angle between two lines drawn from the station of the observer, one to the object observed, the other in the direc-

* This is not really the number cut by the hair, but the number directly under the eye, reflected by the prism. On account of this arrangement, the numbers on the card are reversed with regard to the needle, *i.e.* the 180° is at the north, and the 360° at the south end of it.

tion of north and south as shown by the needle. This last-named line is called the 'magnetic meridian' of the observer.

The magnetic needle does not point exactly to the true north, but varies in direction in different countries. Hence a line drawn through any point in the direction of true north and south (*i.e.* the true meridian of that point) will not coincide exactly with its magnetic meridian, but will make a certain angle with it. This angle is called the 'variation' or 'deviation' of the compass. In England, at present, the deviation is a little over 18° to the west (Plate I., *fig.* 2). It changes from year to year. In 1663 the needle pointed true north. In 1818 it reached its greatest westerly deviation, 24° 41′. Since then it has been returning towards true north at the rate of about 6′ per year. In general, the deviation is to the west in Europe and Africa, and to the east in Asia and America.*

The compass needle is affected by the neighbourhood of iron. Care must be taken therefore not to stand near iron railing, &c., while observing bearings.

In windy weather it is difficult, sometimes impossible, to hold the compass steady enough. To meet this there are various expedients, such as to sit on the ground and steady the elbows on the knees, or to lie down flat and rest the elbows on the ground, or stand the compass on a stone, or a clod.

The Protractor.—The angles observed with the compass are laid down on paper by means of the surveying Protractor, which is an instrument of boxwood or ivory, rectangular in shape, 6 inches long, by about $1\frac{3}{4}$ inch broad.

Its edge, round three of the sides, is divided into 180°.

* The deviation may be found by taking the bearing of the pole star, when exactly above or below the third star from the tail of the Great Bear. The moment of its being so can be ascertained by means of a plumb line. If the bearing is between 0° and 90°, the deviation is westerly; if between 270° and 360°, it is easterly, and the difference between the observed bearing and 0° in the former case, or 360° in the latter case, is the amount of the deviation. The bearing of the shadow thrown by an upright pole at noon will answer the same purpose.

These three sides represent the circumference of a semicircle, the fourth (which we may call the inner side to distinguish it) representing the diameter. In the middle of this side is a mark denoting the centre. The degree divisions rounds the three sides have two sets of numbers, the outer series, 1 to 180, numbered round to the right, and the inner, 180 to 360, numbered the same way. Thus, for every number on the compass card, there is a corresponding one on the protractor. The inner side has a scale of tens and hundreds of yards along its edge.

The paper used for plotting the angles on is ruled with a number of parallel lines, at unequal distances from one another, called north and south lines.

Suppose the point O (Plate I., *fig.* 3) to represent on the paper a spot from which bearings have been taken. The protractor is laid on the paper, with its centre mark at O, and adjusted so that its edge may be parallel to the lines on the paper. If the edge of the protractor does not happen to coincide with one of the lines the parallelism must be judged by the eye. This can be done pretty accurately, as the edge is six inches long. Care must be taken that in adjusting it, the centre is not moved away from O. The edge of the protractor is then supposed to lie in the same direction as the compass needle, *i.e.* magnetic north and south, and it therefore represents the magnetic meridian of O. To lay down any bearing a dot is made at the proper number of degrees on the edge, and a line ruled through O and the dot. To ensure accuracy the dot should be very small and close to the edge. For this a hard pencil must be used with a fine point, and be held upright in making the dot.

It is generally convenient to lay the protractor to the right (or East) of O in plotting bearings under 180° (Plate I., *fig.* 3), and to the left (or West) for bearings over 180° (*fig.* 4). But if O is near the edge of the paper this may be impracticable. Nor is it necessary if we bear in mind the direction in which the bearing must lie. The number of degrees shows this at once. If between 0° and 90°, it is between North and East; if between 90° and 180° it is

between East and South; if between 180° and 270° it is between South and West; and if between 270° and 360° it is between West and North. Plate I., *fig.* 1, shows this clearly; and if this is understood and impressed on the memory, there can be no mistake in plotting a bearing whichever side the protractor is laid.

SECTION III.

MEASUREMENT OF DISTANCES.

Where accurate measurements are required, 'Gunter's chain' may be used. It is 22 yards long, so that 10 chains = 1 furlong, 80 chains = 1 mile. It is divided into 100 links, each 7·92 inches long. Two men are required to use the chain. The leader, who has ten iron arrows to start with, moves on till the chain is stretched, and plants an arrow to mark the spot. He does the same each time he stretches the chain. The follower picks up the arrows, one by one, as he comes to the points where they have been left. When he has all ten he returns them to the leader, who notes the distance measured.

In military sketching, distances are almost always measured by pacing. The sketcher must know the exact length of his pace, and take care to pace uniformly. It is an advantage to pace yards, as it saves trouble and chance of errors in calculation. If the regulation pace of 30 inches is used, the number of yards is found by deducting $\frac{1}{6}$ from the number of paces.

In all plans, the distances shown between the different points are horizontal distances. On level ground, these are found at once by simple measurement, but, where the ground is uneven, the distance between any two points, measured along the surface, up and down the slopes, will of course be greater than the true horizontal distance. The steeper the slope the larger will the difference be. On a slope of 5° it will only be about 14 inches in 100 yards; at

10° it will be nearly 55 inches; at 15°, $3\frac{1}{2}$ yards; at 20°, 6 yards; and at 25°, $9\frac{1}{2}$ yards in 100.

On slopes of 15° and upwards, however, little reliance can be placed on pacing, and on such slopes (as well as on the less steep ones when the line paced is a long one) the distances measured should be frequently checked by methods which will be explained in a later section.

Distances may be roughly estimated by noting the time which elapses between seeing the flash and hearing the report of a gun. Sound travels about 1,140 feet in a second, so that the number of seconds multiplied by 1,140 gives approximately the distance in feet, but this is affected by the state of the atmosphere, direction of the wind, &c. and cannot be depended on for exactness.

SECTION IV.

SCALES.

All maps or plans must be drawn to scale; that is to say, there must be a fixed proportion between distances on the ground and the representations of them on paper. This is necessary, in order that the person using the plan may be able to ascertain, by measurement on the paper, any distance on the actual ground that he may require to know.

This proportion, or scale, must be decided on before the drawing is commenced, and adhered to throughout.

There are two ways of expressing it. One by comparing two units of length with one another; as, for example, when we say that a map is on a scale of one inch to a mile, we mean that a mile length of road is represented by one inch, the width of a river a quarter of a mile wide by a quarter of an inch, and so on.

The other way is by means of a fraction (called the 'representative fraction'), which expresses the proportion between the plan and the ground in figures. Thus, to say that

a plan is on a scale of $\frac{1}{63360}$, means that every line in the plan is $\frac{1}{63360}$ the length of the line on the ground which it represents. This means the same thing as a scale of one inch to a mile, as there are 63,360 inches in a mile, and every length of an inch on the paper represents a length of 63,360 inches, or one mile, on the ground.

The first of these methods conveys more readily to the mind the idea of the scale of a map, but the second has some advantages. We can measure distances on any foreign map, if the representative fraction is given, though we may not know the measures of the country.

For instance, if we have a French map on a scale of $\frac{1}{30000}$, we know that one inch represents 30,000 inches—that is, 2,500 feet—therefore $\frac{1}{10}$ of an inch will represent 250, and $\frac{1}{100}$ of an inch 25 feet, and we can draw a scale of English measures for the map.

It may sometimes be convenient to find the value of a scale from its representative fraction in the form of 'inches to a mile,' rather than that of 'feet to an inch.' To do this, divide 63,360 (the number of inches in a mile) by the denominator of the fraction. Thus, in the case just mentioned, $\frac{63360}{30000} = 2{\cdot}11$, and the French map is on a scale of 2·11 inches to a mile.

These examples show that it is easy to convert the second method of expressing scales into the first. The opposite process is equally simple.

For instance, given a scale of 2 inches to a furlong, to find the representative fraction. We have only to write the two in the form of a fraction, to express the furlong in inches, and to reduce the fraction to its lowest terms. Thus

$$\frac{2 \text{ inches}}{220 \text{ yards}} = \frac{2}{220 \times 36} = \frac{2}{7920} = \frac{1}{3960}.$$

Therefore $\frac{1}{3960}$ is the representative fraction of a scale of 2 inches to a furlong.

In deciding on a scale for a plan, the main question to consider is, what amount of detail is required to be shown in the drawing? At one inch to a mile, a dimension of 10

yards would be represented by $\frac{1}{176}$ of an inch, which is too small to be appreciated by the eye, or measured by any scale. We must, therefore, use a larger scale, if the sketch is required to show objects of that size. At 6 inches to a mile, a length of 10 yards is represented by about $\frac{1}{29}$ of an inch, a dimension which we can recognise and measure. This is the scale generally used for sketches of camp grounds and military positions.

Another point, however, has to be taken into account, viz. the size of the paper on which the sketch is to be made. This consideration may compel us to work on a smaller scale than would otherwise be desirable. For instance, if 15 miles of road have to be sketched, and it is done at 6 inches to a mile, the sketch will be $7\frac{1}{2}$ feet long—a very inconvenient size. For such purposes, therefore, a smaller scale is used, 2 inches to a mile, or even only 1 inch. In such cases it is unavoidable that the dimensions of roads, rivers, &c. should be exaggerated in the drawing, and this is one, among many reasons, which make it necessary that a military sketch should be supplemented by a report.

The surveying protractor has, along its inner edge, a scale of six inches to a mile, the larger divisions representing hundreds, and the smaller ones tens, of yards. To use this in marking off distances on paper, it is laid along the line on which the distance is to be measured, with the 0 of the scale at the point from which we have to measure. The hundreds and tens are counted off, any fraction of 10 yards is judged by the eye, and a dot is made with the pencil at the point so found. In doing this, as in plotting angles, the point of the pencil must be very fine, and the dot must be made close to the edge of the scale, the pencil being kept upright. Unless this is done the distance cannot be marked off very accurately.

A sketcher may happen not to be provided with this 6 inch scale, or may be required to work on any other scale. He ought, therefore, to know how to make a scale for himself, which is easily done, provided that any scale of inches, divided into hundredths or fiftieths, is obtainable.

A single example will suffice to show how this is done.

Suppose a scale of 4 inches to a mile is required. We might draw a line 4 inches long to represent a mile, or 1,760 yards; but the dividing it into hundreds of yards would be awkward, as it would have to be divided into 17 parts and $\frac{6}{10}$ of a part.*

But if 4 inches represent 1,760 yards, evidently 2,000 yards will be represented by a line of some length between 4 and 5 inches. This will be a convenient line both to draw and to divide, if we can find the exact length of it. This is done by simple rule of three, thus:

Yards. Yards. Inches.
1760 : 2000 :: 4 : length required.

Working this out, we find the length to be 4·54 inches; therefore, if we take off $4\frac{54}{100}$ inches from the common diagonal scale, or $4\frac{27}{50}$ from the Marquois scale of fiftieths of an inch, we have a line representing 2,000 yards on a scale of 4 inches to a mile. Dividing this into 20 equal parts, we have hundreds of yards, and again dividing one of these into 10, we have tens of yards.

The dividing of a given line into any number of equal parts is done as follows (Plate I., *fig.* 5):

Let A B be the line to be divided, and suppose that it has to be divided into 7 equal parts. From A draw another line A C, making an angle of about 30° with A B. Judge by eye a length about equal to one-seventh of A B. Open the dividers to that length, and step them 7 times along A C, marking the points 1, 2, 3, &c. Join 7 to B, and through the points 6, 5, 4, 3, 2, 1, draw lines parallel to 7 B. These lines divide A B into 7 equal parts. In the same way one of these parts may be subdivided into any required number of equal parts.

The usual way of drawing a scale for a military sketch is as follows (Plate I., *fig.* 5): Draw, in pencil, three parallel

* The line could easily be divided into furlongs and chains, but it is a rule that military scales should be scales of yards and decimally divided, *i.e.* into tens and hundreds.

lines, about $\frac{1}{15}$ of an inch apart. Measure off on the lower line the total length the scale is to be, and divide it into hundreds of yards in the way just described. Then subdivide the left-hand division into tens of yards. Through the points of division draw perpendiculars, those marking the hundreds reaching as far as the top line, and those marking the tens as far as the middle line only. This is all done in pencil. In inking in, the bottom line is drawn rather thick, the middle line and the divisions thin, and the top line rubbed out, its only use being to keep the perpendiculars the same length, for neatness.

The divisions are numbered as shown in the figure, the 0 being on the right of the tens; a more convenient arrangement than putting it on the left of the whole.

Lastly, the designation of the scale is written over it, either in words, or the representative fraction and the unit of length written at the end.

SECTION V.

CONVENTIONAL SIGNS.

The execution of a military sketch may be divided into two distinct parts, viz.: 1st, the representation of the details; 2nd, the representation of the shape of the ground. They will be described separately in the order in which they are here placed, which, in fact, is the order in which they are usually executed. To carry both out at the same time requires considerable skill.

The first process consists in the delineation of every object on the ground which can affect the movements of troops, whether as communications or obstacles, or as affording facilities for attack or defence; for instance, roads, rivers, woods, and marshes; towns, villages, and houses; walls, hedges, &c.

The way of finding the positions and dimensions of these objects will be explained hereafter. At present we are

only concerned with the manner of representing them on paper.

To draw pictures of them all would be impracticable on the small scale of a military sketch. They must, therefore, be represented by signs; and, as some inconvenience would arise from leaving to each individual the choice of the signs he would use for particular objects, a set of 'Conventional Signs' is laid down to be used for all military sketches. Plate III. contains these* (for a scale of six inches to a mile), and the beginner should practise drawing them, at first copying, and afterwards from memory, so as to become familiar with them.

Bodies of troops should be drawn to scale according to strength. British troops are coloured crimson lake; opposing forces blue. When the same troops are shown in successive positions, different shades of the same colour are used. Day sentries, vedettes, and patrols are coloured red; night sentries, &c. uncoloured.

Fenced roads are shown by continuous, and unfenced by dotted lines. The nature of the roads, whether metalled or not, is written along them when necessary. Care should be taken to draw the roads of the right width and to keep their sides parallel. The words 'Single' or 'Double' are written here and there along the railways. The material of a bridge, iron, stone, &c. is indicated in writing, so also are heath and cultivation, and, if required, the kinds of trees in a wood. In finished sketches, water is coloured Prussian blue; woods, light sap green; main roads, burnt sienna; masonry and railways, crimson lake; wooden buildings, black. For rough sketches coloured pencils may be used.

The titles of sketches and names of important towns are to be in block printing. All other printing to be in italic characters.

* The set can be obtained from any of the Military booksellers.

SECTION VI.

TRIANGULATION.

When we have taken the bearing of any object, we know its direction from the spot on which we stand, and if we take a point on the paper to represent that spot, and plot from it the bearing, we know the direction of the object on the paper; that is, we know that it lies somewhere along the line we have drawn. But, before we can put it down in its proper place, we must find out where it lies on that line, by measuring the distance on the ground, and laying it down on the paper from our scale. We might then return to our starting point, and find, in the same way, the position of a second object, and so on for any number.

This method of finding the positions of points by directing lines is convenient when a number of them lie round our station, and are accessible, and at no great distance from it. But for such as are distant or inaccessible we must employ other means.

Suppose A (Plate II., *fig.* 7) to be our starting point, and that, by taking the bearing and measuring the distance of B from A, we have got B correctly placed on the paper. Then, if we take from A the bearing of a third point C, and plot it, we have a line A *a*, on which C must lie. By doing the same from B, we find a second line B *b*, on which C must also be. Therefore C must be at the point where A *a* and B *b* cross one another, or, in other words, the position of C is determined by the intersection of bearings from A and B. In the same way we can find the positions of any number of other points that are visible from both A and B, without measuring any other distance than that from A to B.

The process of fixing points in this way is called 'Triangulation,' and the measured line is called the 'Base.'

As any error in the base, whether as regards bearing or length, will evidently affect the whole work, care must be

taken to lay it down as correctly as the means at command will admit of. A line should be chosen for the base, if possible, where the ground is fairly level, and free from obstacles; the length should be paced more than once, and the bearing taken from both ends, viz. that of B from A, and that of A from B. It is desirable that the ends of the base should be well marked points, visible from a distance, and easy to find, in case it should be necessary to return there, at any future stage of the work, to correct an error, or for any other purpose.

When the position of any point has been fixed in this way, it may be used as a station from which to take the bearings of other points. For example, if D (Plate II., *fig.* 7) is a point whose position has to be found, and which can be seen from B and C, but not from A, we can fix it by bearings from B and C; and this process may be extended, so as to embrace the whole of the ground to be sketched within a set of triangles, the angles of which are marked by the most prominent objects, placed in their true positions, and forming so many starting points to work from in sketching the details within the triangles, which is done by methods to be described in the next section.

These triangles ought to be as nearly equilateral as possible, so that the intersections which determine the several points may be neither very acute nor very obtuse.

There are two reasons for this. One is that when two lines cut each other at a very acute, or very obtuse, angle, it is not easy to determine the exact point of intersection, while, if the angle is anywhere near a right angle, the point is quite distinct (Plate II., *fig.* 8, *a b c*). The other reason is that, the further the angle is from a right angle, the greater will be the difference made in the position of the point by a small error, either in observing or plotting the bearing (Plate II., *fig.* 8, *a b c*).

If any point is very distant in proportion to the length of the base, the intersection of the bearings which fix it must necessarily be acute (Plate II., *fig.* 8, *a*). For this reason the base ought to be near the centre of the ground,

and of a length proportioned to its extent. For small sketches of one or two square miles, the base should be about one-third the distance across the ground.

It may be impossible, in broken country, to find a good base of such a length. In this case the following expedient may often be used with advantage: Suppose A and B (Plate II., *fig.* 9) to be two points, suitable in other respects for the ends of the base, but that obstacles between them prevent direct measurement of the distance. A shorter line C D may be found, somewhere between A and B, which can be measured by pacing, and from the ends of which A and B can be fixed. These points can then be used, as if A B had been a regularly measured base.

Though the intersection of two bearings is sufficient to fix the position of any point, still there is always liability to error, and it is often useful to apply some test of the correctness of the work. This may be done by taking 'check bearings,' as in the following example (Plate II., *fig.* 10):

With A B as a base, the points C, D, E, have been fixed. Then, if from C the bearings of D and E are taken, the lines, when plotted, will pass exactly through those points if the work is correct. If they do not do so, there has been some error.

These check angles are especially useful to verify points which have unavoidably been fixed by intersections too acute or obtuse to be quite reliable; and many other cases occur in which they are of use.

We have seen how to find, on our paper, the position of a point at a distance from us by taking its bearings from two known points. We must now consider the opposite case viz. when we are ourselves standing at the unknown point, and want to find its place on the paper. We can do so, provided we can see from it two or more of the points whose positions we have fixed.

This process is called 'Interpolation,' and is founded on the simple facts that, if A is north of B, B is south of A; if C is west of B, B is east of C; and so on with regard to any two opposite directions on the compass; or, in other words,

if A and B are any two points, and we stand at A and take the bearing of B, and then go to B and take the bearing of A, there will be a difference of 180° between the two bearings.

The way of proceeding is as follows: We are standing somewhere, but do not know exactly where, between the points A, B, and C (Plate II., *fig.* 11), whose positions we know, and all of which we can see. Taking the bearing of B, we find it to be 212°. We know, then, that if we were at B and took the bearing of our unknown point from it, that bearing would be $212° - 180° = 32°$. If, then, we plot from B a line B*b* bearing 32°, we must be somewhere on that line. Again, if from our unknown point we take the bearing of A and find it 293°, we know that the bearing of the point from A would be $293° - 180 = 113°$, and if we plot from A a line A*a* bearing 113°, we must be on that line also; therefore, we must be at X, where A*a* and B*b* intersect. To save trouble and guard against accidental error in adding 180° to, or deducting 180° from, any observed bearing, we may refer to the protractor, which is so graduated that any number in the outer series differs from the corresponding number in the inner series by 180°.

The rule given before, that acute and obtuse intersections are to be avoided, holds good here also, and for the same reasons. We must, therefore, if we can, choose our points so that the intersection of their bearings may be near a right angle. If the intersection is not a good one, or if we wish, for any other reason, to test its correctness, we can do so by a check bearing, provided we can see a third known point. If, in addition to the bearings of A and B, we plot that of C in the same way, the latter will, if the work is correct, pass through the intersection of the other two.

The cases in which interpolation is useful are numerous. For instance, in making a triangulation there may be points which it is desirable to fix, but which can only be seen from one of our known stations. By moving about the ground, a spot may be found from which they are visible. Having fixed the position of this spot by interpolation, we may use

as a station from which to take a second bearing to the points in question.

Again, after the triangulation is completed, there may be reason, at any time during the work of sketching the details, for suspecting that some error has crept in. The true position being found by interpolation, the error, if any exists, can be discovered and corrected.

A few practical hints on the manner of executing a triangulation may be of use to the beginner.

In the first place, the requisites of a good base may be recapitulated.

It should be level and free from obstructions.

Most of the principal points on the ground should be visible from the ends.

The ends should be marked by easily recognisable points.

It should be centrally situated, and of a length proportioned to the size of the ground.

The sketcher, stationing himself at the end of the base at which he intends to begin work, takes the bearing of the other end, and paces the distance to it. From it he takes the bearing of the first end, and paces back. The two bearings, if carefully taken, will differ by 180°. If they do not, there must have been some accidental error in one of them, which can be checked at once by taking the bearing again. Nor can there be any material discrepancy between the two measurements if the pacing has been done with care. If they do differ, the distance should be paced a third time, when it becomes necessary in the course of the work to go to the other end of the base again. If two out of the three pacings agree, they may be taken as giving the correct length. If all three differ slightly, the mean may be taken.

The next step is to observe all the bearings which it is intended to take from the present station. It is a good plan to write down in the corner of the sketching paper, or in a note book, the names of the different objects, before beginning to use the compass, placing them in the order in which they come, looking from left to right or from right to left.

When several angles are to be taken from the same point, it is an advantage if a rest can be contrived for the compass, so that it can be turned on each point in succession, and the bearing of one written down while the card is settling for the next. If no rest can be found, and the compass has to be held in the hand, two or three bearings may be taken at once, without removing the compass from the eye, by turning it slowly from one point to another. This saves much of the time that is lost by the swinging of the card before it settles; but care must be taken not to observe more angles at a time than the memory can retain distinctly, before writing them down.

It is a saving of time to take all the bearings at once, before plotting any, for, by plotting all of them at once, repeated adjustments of the protractor are avoided, the number of degrees in each being lightly written in pencil close to the dot.

Lines are then drawn from the end of the base through the dots, and in doing this it is useful to estimate roughly the distance of each point, so that the line may be drawn at once long enough to pass through it; greater correctness is obtained in this way than if the line is drawn too short at first and then prolonged.

As each line is drawn, the name of the object to which it belongs is lightly written in pencil along it, so as to avoid confusion among a number of lines (Plate II., *fig.* 12).

When this work is completed at one end of the base, the sketcher proceeds to the other end, and from thence takes the bearings of the several objects in the same manner as before. As each point is fixed by the intersection of the bearings, a small ring is drawn round it, and its name written close to it. The names written along the lines, and the superfluous ends of the lines, beyond the intersections, are then rubbed out. It is always an advantage to keep the paper as clear as possible, by rubbing out all dots, lines, &c., when no longer required.

When the work at the base is finished, the triangulation is completed by visiting such of the points, just fixed, as it

may be necessary to use as stations, for the purpose either of fixing, by a second bearing, any object that has only been seen from one end of the base, or of taking bearings to new points which it is desirable to fix, or of verifying, by check bearings, any intersections of the correctness of which there may be a doubt.

It is often useful to fix on the paper the positions of conspicuous points which are near, though not actually on, the ground which is to be sketched. Such points may be useful for interpolations when working near the boundary of the ground; and when, as is often the case, a large piece of ground is portioned out to be done by different individuals, the occurrence of some of the same points on two sketches will facilitate the piecing of them together. Distant points should be fixed from stations far apart from one another, so that the base of each triangle may be in proportion to the sides, and acute intersections be avoided.

An example of a triangulation is given below. The plotting of it is shown in Plate IV., but the learner will find useful practice to plot it for himself, observing the rules given above, as far as they are applicable.

Example of a Triangulation.

Angles observed from A (a tree in a field).

E (top of church steeple) . . .	20° 30′.
D (guide post at cross roads) . .	97°.
C (chimney of house)	129°.
B (stile at bend of road) . . .	161°.
K (shed at corner of field) . . .	175°.
F (vane on top of house) . . .	200°.
H (signal post on railway) . . .	328°.

The distance from A to B, being twice paced, is found to be 690 yards.

Angles observed from B.

E	3°.
C	27° 30′.
D	53° 30′.

F	260°.
G (telegraph post)	289°.
K	325°.
A	341°.

It will be observed in the above:

1st. That the bearings of B from A, and of A from B, agree.

2nd. That the positions of the following points are determined, viz. E, D, C, F, K, and that all the intersections are good ones, except that for E, which is rather acute.

3rd. That the positions of H and G are not determined, only one bearing having been taken to each, as neither of them can be seen from both ends of the base.

To verify the position of E, its bearing is taken from D, and found to be 328°. This passes through the intersection of the bearings from A and B. E is therefore taken to be correctly fixed.

By moving about the ground, a point X is found, on the edge of a railway cutting, from which both H and G can be seen. A and F are also visible. The position of X can therefore be found by an interpolation, and it can be used as a station for fixing H and G.

Interpolation to find X.
Bearing of A from X 97°.
,, ,, F ,, X 146°.
Angles observed from X.
H 29° 30′.
G 227°.

All the points are now fixed, but it is considered advisable to test the correctness of the whole work by a check bearing.

Accordingly, from H, the bearing of E is taken and found to be 81°, which passes exactly through the position of E as previously found. The correctness of the work may therefore be considered to be established.

A plot of the above triangulation is given on Plate IV.

SECTION VII.

TRAVERSING AND DETAILS.

The triangulation being completed, the next step is to put in the details within the triangles. Of these, the roads generally claim attention first, both on account of their importance, and because, in the course of sketching them, so much of the rest gets worked in, that often little or nothing remains to be done to complete this part of the sketch.

Roads are sketched by a process called traversing, which is very simple.

The sketcher chooses a convenient spot to start from (either one of the points fixed by the triangulation, or one which he can find by interpolation), and from it takes a bearing forward in the direction he means to work in. He plots the bearing, paces the distance, and marks the point on his paper, and then uses it as a fresh station, from which to take a forward bearing. Proceeding as before, he gets a third station on his paper, and continues to work in the same way, till he reaches the boundary of his sketch, or closes on some point in the triangulation, which he can then use as a fresh starting point, to commence work in another direction.

While pacing from one station to another, the sides of the road are drawn, the proper width being given to it according to scale. It is not at all necessary that each forward bearing should be taken along the middle of the road. On the contrary, much time will be saved, without any loss of correctness, by taking the bearing of the furthest point that the bends of the road will allow to be seen. Care must, however, be taken to pace on that point in a straight line. The sides of the road will be at varying distances from this line (which may even touch one or both of them at different points), and must be drawn accordingly, the distance being judged by the eye.

The sketcher also marks down any cross road or lane, as

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he comes to it, taking its direction with the compass, and drawing the sides for a short distance, so that he can return to the spot afterwards, and traverse the cross road if he should have occasion to do so.

Any stream crossing the road is treated in the same way, bearings being taken up and down, and an arrow drawn to show the direction of the current. The bridge, if any, is also drawn.

In a similar manner any railways, or canals, which the road crosses, are shown, and hedges, boundaries of woods, &c., are sketched in.

Houses and other buildings are also drawn in their proper places, those immediately on the road being put in as they are passed. Those which are at a short distance from the road, and accessible, may be put in as follows: The sketcher when exactly opposite to the building halts, and paces the distance to it at right angles to the line on which he is advancing. He should make a mark in the road where he leaves it, so that he may return to the exact spot to continue his traverse.

A line measured in this way, perpendicular to the line of direction, is called an 'offset.'

In military sketching, the right angle of the offset is judged by eye, and not measured with any instrument, and the length also, when not great, is often judged instead of being paced.

Buildings that are too far off to be put in by offsets, should be fixed by intersections of bearings taken from convenient points (Plate V., *fig.* 13).

The line of direction, from station to station, is generally drawn for convenience in measuring distances along it, and offsets from it, but it is rubbed out when the work is inked in. It should, therefore, be drawn very lightly in the first instance, not only in order that it may be completely obliterated afterwards, but also because, for the sake of distinctness in the drawing, any lines of this sort, required only for temporary purposes, should be made as inconspicuous as possible. For the same reason, on reaching a station, the

superfluous length of line beyond it should be rubbed out at once.

When offsets are taken, the perpendiculars are not drawn at all, but the points to which they are taken are marked down at once, by measuring the distance from the scale.

Traversing is applicable to rivers, to borders of woods and marshes, and to boundaries of any kind, as well as to roads.

When a very irregular line, such as a stream or boundary, has to be sketched, it is advisable to take as distant points as possible on it for forward bearings, thus cutting off several bends, which can be put in by offsets (Plate V., *fig.* 14). Not only is this way more expeditious, but it is more accurate than traversing all the bends.

For example, by taking a bearing from A to B, and offsets as shown in the figure, the position of B is found correctly, and the errors in laying down the course of the curved line are likely to be small, while, if all the bends between A and B were traversed, there would probably be a considerable error in the position of the latter point.

In commencing a traverse, if any error is made in observing or plotting the bearing from the first station, or in pacing or setting off the distance from it to the second, the latter will be wrongly placed on the sketch. Consequently the third station, the correctness of which depends on the bearing taken, and distance measured, from the second, will also be wrong, and every subsequent station will, of course, be affected.

If any further mistake is made between any two stations, it will put all that come after still further out of their true places; that is, to the extent of both errors added together; and as every mistake, during the whole work, tells in the same way, the error at the end, which is an accumulation of them all, is likely to be considerable.

A certain amount of inaccuracy is unavoidable in military sketching. To say nothing of mistakes due to forgetfulness or inattention, the imperfection of the means employed makes perfect accuracy impossible.

In the angles, fractions of a degree can neither be read

nor plotted. Unevenness of ground must affect pacing to some extent, nor can distances be set off exactly to a yard or two; and though each single error due to these causes may be very small, still the accumulation of them must tell.

Hence traversing, by itself, is not entirely to be relied on, and this shows the advantage of having a good triangulation to start with. The principal points on the ground having been correctly fixed, we can ensure that no considerable error arises in the work. Either each separate portion of the traversing may be commenced and closed on known points, or, if this is impracticable, the work may be checked from time to time by bearings taken on some of them. When it is certain that the line of direction is correct—as, for example, in pacing from one known point, A, on another, B (Plate V., *fig.* 15)—it is only necessary to check the distance paced, and this can be done by one bearing, taken on a third known point, C; but where the direction has been changed several times, an interpolation on two known points is needed.

The sketcher must judge for himself when, and how often, such checks are required. As a rule, they should be applied more frequently when the pacing has been over rough ground, or up and down steep hills.

The main roads, being among the most important features in a military sketch, should be correctly drawn. Bye roads and lanes are often very tortuous, and to traverse them regularly would be very laborious. Being of less importance than the main roads, they may often be put in by more expeditious methods, such as, finding, by interpolation, the positions of the principal bends, and sketching the intermediate parts by eye, or, if the country is open, by cutting off bends and taking offsets as already described. The course of a stream may be sketched in a similar manner, when obstacles interfere with pacing along the bank. Edges of marshes or creeks may be treated in the same way.

Hedges can generally be put in with sufficient accuracy, while traversing the roads, by observing the points where they branch off, and their directions, and by judging the

distances of those that are parallel, or nearly so, to the road. Where a hedge forms the boundary between wood and cultivation, or cultivation and heather, &c., it is of more importance to give its position correctly, than where it merely divides one field from another, and in such cases the direction may be taken with the compass.

Watercourses are important features (as will be seen in the sections on contouring), and should not be neglected. Railways must of course be shown, but it is seldom necessary, nor would it be easy, to traverse them. The pacing would be difficult, and the iron would probably affect the compass. They can be traced by fixing points on them by intersections, or by offsets, or by noting where they cross the roads. Cuttings and embankments on them, and also on the roads, must not be omitted.

It is needless to enumerate all the minor details which may be met with. The various ways of finding their positions have been explained, and the sketcher must judge for himself, in each case, which will be the best method to employ.

It often occurs that a sketch of a road has to be made for several miles on end. Triangulation is impracticable here; consequently no check bearings can be taken, and reliance must be placed on the correctness of the traversing.

Often, however, means may be found of checking this. Milestones, if they exist along the road, will answer the purpose. If a map of the country is obtainable, the distances from the starting point, and from one another, of the chief landmarks, such as cross roads, villages, bridges, &c., may be measured and noted down. Or even the general outline of the road may be traced on the paper before starting, whatever may be the scale of the map, by a process which will be explained in a later section.

SECTION VIII.

SKETCHING WITH FIELD BOOK.

A military sketch is usually plotted at once on the ground, the sketcher having his drawing materials with him, and completing the work in pencil as he goes along.

There is, however, another way of working, viz. by recording the several observations, as they are made, in a book called a 'Field Book,' and plotting them at a future time.

This method is useful in certain cases, such as, when drawing materials are not at hand, or when the weather is so bad that it is impossible to draw, or where secrecy in making the sketch is an object. The out-door part of the work can be done more expeditiously than by plotting it at once, though the whole takes longer to complete.

There is one disadvantage in this way of sketching. If the work is plotted at once on the ground, any great error, accidentally made, either in a bearing or distance, has a good chance of being detected by the eye, which is not the case if the observation is simply recorded. If such an error be discovered afterwards, while plotting the sketch, it will generally be necessary to revisit the ground to correct it.

Recording a triangulation in the field book is very simple, and the example given in the last section is sufficient to give an idea how it may be done. But a road traverse is more complicated, though by no means difficult, when the conventional way of keeping the field book is explained.

As a first principle, the sketcher should always allow himself plenty of room in the book, and not try to economise space by crowding the work—a common mistake with beginners, and one which generally leads to hopeless confusion in the plotting. The work should be kept as clear and distinct as possible, so that, if the necessity should arise, any other person may be able to plot it.

Any ordinary note book of convenient size may be used to record a road traverse, the only preparation required

being the ruling of two parallel lines, about half an inch apart, down the middle of each page. Between these lines are written the number of the station, the forward bearings from station to station, and the distances paced from one to another. All offsets and bearings taken to either side are entered outside the lines, on the side to which they belong. To enable this to be done conveniently, the entries begin at the bottom of the page and work upwards, *i.e.* in the same direction as the sketcher is going.

The space between the two lines is merely for the purpose of writing the necessary figures, and does not represent any distance on the ground. The lines representing the sides of the road are drawn outside, continuous for a fenced, and dotted for an unfenced, road (Plate V., *fig.* 16), and, if great correctness is required, their distance from the line of pacing at different points may be entered between.

In commencing a traverse, the sketcher numbers the station, and takes a bearing to the next, which he enters in the centre space, with the word 'forward' opposite to it in the margin. Any other bearing taken from here is entered in the margin on the proper side, with the name of the object.

He then paces on till he has occasion to take an offset or a bearing, when he enters in the centre column the number of yards paced, and opposite to it, in the margin, the number of degrees in the bearing, or the length of the offset, with either the name of the object, or its conventional sign.

Offsets are always measured from the line of pacing, and not from the edge of the road.

When a bearing is taken along a bye road, hedge, or stream, they are drawn instead of writing their names.

In continuing the pacing from the spot where he halted, the sketcher takes up the counting from where he left off, and does not begin at 1, 2, &c. again, so that the number of paces in the centre column is, in every case, the total number from the last station.

On reaching station 2, a line is drawn across the page, above the total number of yards; station 2 is numbered, a

forward bearing taken and entered, and the work carried on as before, a fresh numbering of paces being commenced.

When the road passes cuttings, embankments, woods, marshes, &c., such changes may be noted in writing, or by the proper conventional signs.

The plotting of a traverse from the field book is done in the same way as on the ground, but when check bearings have been used to correct the work, it is advisable to plot only the stations and line of pacing from one to the other, in the first instance, and then apply the checks; for if any error is discovered by their means, there is only one line to rub out. When the stations are all verified, we can go back to the beginning and plot the details.

An example of a page of a field book, and the plotting from it, is given in Plate V., *fig.* 16, from which the beginner may learn the conventional way of making the ordinary entries.

SECTION IX.

SKETCHING WITH THE PLANE TABLE.

The plane table (Plate VI., *fig.* 17) consists of a smooth board about a foot square, mounted on a tripod stand by a ball and socket joint, so as to turn about freely, with a clamping screw to fix it when required. The sketching paper is stretched on the board, and held down by a frame, which fits on round the edge and clips the margin. A ruler is used which has a bevelled edge with scale of yards on it, and two sights, one near each end, which turn up and down on hinges. One of these has a slit down the centre, the other a hair, the line through the slit and hair being parallel to the bevelled edge.

Angles laid down with the plane table are not referred to a fixed meridian as compass bearings are, but are the angles between lines from the observer's station to the several points observed. To lay them down, the ruler is placed with its bevelled edge touching the point which represents the

station on the paper. The observer looks through the slit, and pivots the ruler till the hair covers the object; a line is drawn along the edge, and the ruler turned on the other objects in succession, the edge being always kept in contact with the station. More accurate angles can be laid down in this way than with compass and protractor, for with them fractions of degrees can neither be read nor plotted, while the plane table gives the exact angles, whatever be the number of degrees, minutes, and seconds in each.

The one thing essential with the plane table is that the paper be kept throughout the work in the same position with regard to the ground that it had at the commencement—that is, that every line on the paper be always parallel to the corresponding line on the ground.

The processes employed in sketching with the plane table are the same as with the compass, differing only in the manner of executing them. A triangulation is made, the details are completed by traversing, and interpolation can be had recourse to to check errors, or for other purposes.

To make a triangulation, a base A B (Plate VI., *fig.* 18) is selected and measured, and a line *a b* drawn to represent it; the table is set up at A, the ruler laid along *a b*, and the board turned till the sights cover B. The paper is then in the direction with regard to the ground which it must retain all through the sketch. The ruler, pivoting on *a*, is turned successively on C, D, E, &c., and lines drawn along it. The base is then measured, and the table set up at B, and adjusted with the ground by laying the ruler along *b a*, and turning the board till the sights cover A. This adjustment by the 'back angle' is always a necessary preliminary to commencing work at a new station. The ruler is then pivoted on B and turned on the several points successively; lines are drawn along the edge which will intersect those drawn from A, and determine the positions of the points. Any one of these can now be used as a station for further observations. For example, to fix E, we can set up the table at D, and adjust it by either A or B; laying the ruler along *d a* or *d b*, as the case may be, and bringing

the sights into alignment with A or B. The ruler is then pivoted on D to determine the position of E.

Traversing is carried on on the same principle. At starting, the paper must be adjusted by some known point. The direction of the next station is then laid down. On reaching it an adjustment by the back angle is necessary (Plate VI., *fig.* 19) before the forward angle is laid down, and the same is the case at every station. If the traverse is not made in connection with a triangulation, but is an independent piece of work, we assume the first station on the paper and the direction of the second, adjust the table by this line, and then proceed as above described.

In interpolating with the plane table a difficulty arises from want of means of adjusting the paper with the ground when at an unknown point. If, however, we can place ourselves in line with two known points, and can at the same time see a third, an interpolation is easily made. Suppose A B (Plate VI., *fig.* 20) to be two points on the ground, represented by *a* and *b* on the paper; placing ourselves in line with A and B, and laying the ruler along *a b*, the table is turned till the sights cover A and B. The paper is then right with the ground, and we have a line, *b a*, produced, on which we must be standing. Taking a third known point, C, the edge of the ruler is placed against *c* (its representative on the paper) and pivoted on it till the line from C through the sights meets the eye. A line is drawn along the edge, the intersection of which with *b a* produced fixes our position.

If we cannot obtain a directing line in this way, we can interpolate by means of three known points as follows: A small piece of transparent paper is pinned down anywhere on the board, and a station O (Plate VI., *fig.* 21) assumed on it at random. The ruler, pivoting on O, is turned on A B C (the three points), and lines drawn towards them. The transparent paper is then taken up, and being laid on the sketch so that the middle line passes through *b* the middle point, is moved about (always keeping the middle line on *b*) till the other two lines pass through *a* and *c*. The point O

then determines our position, and is pricked through on to the sketch.

The plane table is often provided with a compass in a small drawer fixed underneath the board, which only comes out far enough to allow the tip of the needle to be seen (Plate VI., *fig.* 22). There is a mark on the inside of the drawer at this end, and when the table is first set up it is turned about till the north end of the needle points to this mark. If the same is done at all future stations, the paper is adjusted with the ground without the necessity of using the back angle. In this case we can interpolate without placing ourselves in line with two known points. Adjusting the paper by the compass, and selecting two points, A and B (Plate VI., *fig.* 22), the ruler is pivoted successively on the corresponding points *a* and *b*, till A and B are seen through the sights. The intersection fixes our position.

The method of sketching known in the service as 'eye sketching' is merely the use of the plane table in its simplest form. The board has no stand, but is laid on the ground; the ruler has no sights, but is simply a straight edge of wood with a scale on it. This edge is aligned on any object by the sketcher, who steps back a pace or two to look along it. In other respects the process of adjusting the paper, triangulating, &c., are the same as those described above. The method is a rough one, but on open ground, with care, a fair approach to accuracy can be made.

SECTION X.

FEATURES OF GROUND.

The shape of ground depends mainly on the geological formation of the country. This question cannot be fully discussed here; but certain typical features may be described, which are found everywhere, and by the combination of which, in an endless variety of ways, all hilly ground is formed.

What is generally understood by a 'hill' is a piece of elevated ground, with a top of any shape, regular or irre-

gular, from which the ground falls in all directions. When the hill is small, it is often called a 'knoll.' If the top of a hill is of considerable extent and level, or nearly so, it is called a 'plateau' or 'table land.' Where a hill is narrow in proportion to its length, it may be described as a 'ridge.' The top of this ridge may be level for the greater part of its length, only commencing to fall towards the ends, or it may slope downwards both ways from a point at or near its middle; or, again, it may be broken into a series of alternate rises and falls, this last being the case of most frequent occurrence when the ridge is a long one. These dips, or depressions, vary in depth, the deeper ones constituting the passes through the range. The shallower depressions are often called 'saddles' from their shape. Low hills with gentle slopes form what is called 'undulating ground.'

A hill may stand alone; but more frequently it forms one of a group of hills, either rising here and there from an elevated plateau, or connected by ridges, straight or bent, simple or branched.

The sides of the hills and ridges are generally broken into bulges and hollows, more or less marked, called 'salients,' and 're-entrants,' respectively.

From the former spring the 'spurs,' which form the under features of the hills, and which, in fact, are smaller ridges projecting from the main one, either at right angles or obliquely, and varying in size and shape: short, rounded and abrupt, or long and sloping gradually, or stretching out far with nearly level tops, in which case they often end in a slight rise or knoll.

The re-entrants form the heads of the valleys, which may be straight, curved, or branched, with sides of varying degrees of steepness. When a valley is deep and narrow, with sides sloping abruptly, it is called a 'ravine.' Through the bottoms of the valleys run the watercourses, by which the water, from springs in the hills, or from rain falling on them, finds its way to the nearest river, or to the sea.

If we stand at any point on the top of a ridge, facing along it, we see that the rain which falls on the ridge will

run down, partly to our right hand, partly to our left, according to which side of the ridge it falls on. There must therefore be a line along the top, on which the water parts, to run in these two opposite directions, or, in other words, a line from which the slope downwards each way commences. This is called the 'watershed,' or 'water-parting' line. Every ridge or spur of any kind must have its watershed line, not necessarily straight, but often very irregular in direction, and often not very clearly defined.

These lines, together with the watercourses, mark out the shape of the ground, and an experienced sketcher, having these traced for him, and the heights of some of the principal points given, may make a fairly correct sketch of a piece of hilly ground without seeing it.

There is generally little difficulty in recognising which of the above-named features of ground we may be standing on at any moment. The following simple rules * may serve to guide the beginner:

Observe the rise and fall of the ground in four directions, opposite, and at right angles to each other.

If the ground falls in all four, we are on a hill.

If it falls in three, and rises in one, we are on the watershed of a ridge or spur.

If it rises in three, and falls in one, we are in the watercourse of a valley.

If it falls and rises in alternate directions (say rises to front and rear, and falls to right and left), we are on a saddle.

Plate VIII. is an example of a sketch of hilly ground, illustrating the manner in which several of the above described features are represented, but in order to understand it the next section must first be studied.

SECTION XI.

REPRESENTATION OF HILLY GROUND.

In all sketches made for military purposes, it is essential that the form of the ground should be represented. The posi-

* From Captain Lendy's *Practical Course of Military Surveying.*

tions of the hill tops, the shapes and directions of ridges, spurs, and watercourses, the steepness of the slopes, and the relative heights of different points, must all be shown.

Some conventional means must therefore be devised by which these particulars may be shown, both with accuracy, and in such a manner as to convey the required information readily to the eye.

The system of representing ground by 'contours' answers both these conditions, and has been adopted for military sketches.

A contour is the intersection of the surface of the ground with a horizontal plane; or it may be defined more simply, as an imaginary line running along the surface of the ground and keeping on the same level throughout its whole length.

The following illustration may help in arriving at a clear understanding of these definitions:

Suppose a tract of hilly ground to be immersed under water, and that the water sinks, by successive equal stages, a certain definite number of feet at a time. We can easily conceive what would happen as this went on. The tops of the hills would first appear as islands, then the ridges connecting them would gradually show themselves. As the water still sank, the spurs and the heads of the valleys would begin to be marked out, and the forms of these lower features would continue to develop themselves, till at length the water reached its destined permanent level.

Now suppose that, at the end of each stage of its subsidence, the water left a mark on the ground; each line thus traced would evidently be continuous, and at the same time level throughout its length. Each one would also be at the same vertical distance above and below its next neighbours.

These lines would be strictly contours, according to the definition; and, by traversing and plotting each in the ordinary way, we might make a complete contoured sketch of the ground.

We are all familiar with the way in which the shape of the coast line of a country is shown in ordinary geographical

maps; how the water line stretches out from the land to embrace capes and promontories, and recedes into the land up the sides of inlets and arms of the sea, as far as the tide reaches.

Now the sketch we have just imagined would be a series of coast lines, marked at the several successive levels of the water; and, as each line would give the true shape of the land at its own level, it is evident that the set of lines gives a true representation of the shape of the whole.

Besides the general form of the ground, the contours show the degrees of steepness of the different slopes.

Bearing in mind that the distances shown in a plan are horizontal ones (*see* Section III.), suppose two points on sloping ground, one of which is a given number of feet higher in level than the other. Evidently, the gentler the slope the further apart will the points be on the plan, and *vice versâ*; or, to put the case more simply, we have to walk further on an easy slope to ascend a given height than we have on a steep slope.

Consequently, the steeper the slope the closer together will be the contours, and the gentler the slopes the further will they be from one another.

We may verify this fact for ourselves, by standing on a sea beach, and observing the difference between high and low water mark. Where the beach slopes very gradually, the sea, on the fall of the tide, recedes to a considerable distance; but where it shelves steeply, the distance is but small, the level of the water being, of course, at any moment the same at both points.

It has been supposed, in the illustration given above, that the contours are at definite and equal vertical intervals one above the other, and this condition is essential to the true representation of ground by means of them. If we know what this interval is on any plan, we can find the actual height of any point above the lowest part of the ground, or the relative heights of any two points, by simply counting the contours, provided we understand how to read a contoured map sufficiently well to be able to distinguish

whether any contour is higher or lower than its next neighbour on either side (*see* Section XV.)

For the sake of uniformity in military sketches, it has been considered necessary that a certain vertical interval between contours should be fixed upon and adhered to.

Two considerations influence the choice of this.

If it is made too great, the contours will not show the smaller features of the ground.

For instance, if it is 50 feet, there are no means of showing a hill 40 feet high; while if it is 20 feet, the same will be shown by two contours, one round the top and one round the middle. Hence, the smaller the interval, the more faithfully is the ground represented.

But, on the other hand, the smaller the interval, the more numerous will be the contour lines; and this, if carried to excess, greatly increases the labour of making a sketch, besides tending to obscure the other details. Either extreme, therefore, should be avoided.

The rule laid down is, that for sketches at 6 inches to the mile, the vertical interval between contours is to be 20 feet. It is considered that this enables the ground to be shown with sufficient minuteness for military purposes. When the scale is 12 inches to the mile, the greater space occupied on the paper allows room for more contour lines without crowding, and the interval is fixed at 10 feet. On the other hand, at 3 inches to the mile, where the space is smaller, 40 feet is the regulated vertical interval, which is thus made inversely proportional to the scale of the map.* It follows from this, that, for the same slope, the contours will always be the same distance apart, whatever be the scale of the map. For instance, on a map at 12 inches to a mile there will be twice as many contours as on a map of the same ground at 6 inches to a mile, as every 10 feet of vertical rise will be indicated by a contour instead of every 20. But on the 12 inch map the contours denoting each 20 feet of rise would be twice as far apart as on the 6 inch map, so that by inserting midway

* It is laid down, however, that this rule is not to preclude the use of any other vertical interval when circumstances may render it desirable.

between every two the contours indicating the 10 feet rise, we shall have them the same distance apart on both maps. For similar reasons, at 3 inches to a mile, the contours denoting 40 feet of rise will be at the same distance from one another as those denoting 20 feet at 6 inches to a mile, every distance on the 6 inch map being reduced by one-half, and every alternate contour suppressed. A great advantage gained by this is that the eye becomes accustomed to the distances apart of the contours for different slopes so as to recognise them readily.

If a sketch has to be made on any other scale than 3, 6, or 12 inches to the mile, the same relation can be mantained, the proper vertical interval being found by inverse proportion; thus, for 2 inches to a mile—

$$2 : 6 :: 20 : 60;$$

therefore, 60 feet is the vertical interval to be used.

It has been said that a contoured sketch of ground may be made by traversing the several contours, and, in fact, this is what is done, when great accuracy is required for any engineering purposes. A series of points, at the regulated vertical intervals, one below the other, is found by means of levelling instruments. Taking each of these as a starting point, a continuous series of points, on the same level with it, is found (also by levelling), and marked out by pickets. Finally, the whole set of contours is traversed and plotted.

This, however, is a very laborious process, and, from the time it takes, is unsuitable for military sketches. For these another method is used, which is far more expeditious, and sufficiently accurate for the purpose. The principles on which it is founded, and the way of carrying it out, have to be explained.

Slopes of ground, or gradients as they are called, may be denoted, either by the number of degrees in the angle which the slope makes with a horizontal line, or by the proportion between the height and base of the slope, put in the form of a fraction, of which the height is the numerator, and the base the denominator.

Thus, we may speak of a 'slope of 30°,' or a 'slope of $\frac{1}{2}$,' both meaning practically the same thing. The fraction $\frac{1}{2}$ implies that, for every 2 feet of horizontal distance, there is a rise of 1 foot of vertical height.

This manner of expressing slopes falls in with the ordinary way of speaking. 'A rise of 1 in 50,' 'A fall of 1 in 220,' and so on, are common expressions, conveying their own meaning to the mind.

By using this form, we can find, by simple arithmetic, the length of base of any portion of a slope, if we know the vertical height, and the gradient.

Thus, suppose two points on a slope of $\frac{1}{15}$, one of them being 20 feet higher than the other; then, as there is a rise of 1 foot of height for every 15 feet horizontal, there will be a rise of 20 feet, for $20 \times 15 = 300$ feet horizontal, which will be the length of base of the supposed slope, *i.e.* the distance of the two points from one another on a plan.

When the slope is given in degrees, we can arrive at the same result by trigonometry, or we may do so by geometrical construction as follows:

Draw two lines parallel to one another, at 20 feet apart, by any convenient scale (Plate VII., *fig.* 23). From any point A in the lower line, plot the given angle, say 4°, which is nearly the same slope as $\frac{1}{15}$, and draw the line far enough to cut the upper line. From B, the point of intersection, let fall a perpendicular B C on the lower line. Then, by measuring the length of A C (by the same scale as was used to measure the 20 feet distance between the lines), the length of base of the supposed slope is found.

If this is correctly done, the result will agree very nearly with that obtained above by arithmetic. It will not agree exactly, for 4° is not exactly, though very nearly, the same slope as $\frac{1}{15}$. As a matter of fact, the length of A C is 286, instead of 300 feet, and trigonometry will give the same result.

It appears, then, that for a height of 20 feet and a slope of 4°, the horizontal distance, or base, will always be the same. And, similarly, for a height of 20 feet, any other

degree of slope will have its own fixed definite length of base.

These distances are called the 'horizontal equivalents' of the several slopes for the given height, *i.e.* 20 feet.

A table of horizontal equivalents for every degree of slope, and for any given height, may be made by the above construction.

An example is given in Plate VII., *fig.* 24, in which the equivalents of 5°, 10°, 15°, 25° (viz. A B, A C, A D, A E respectively), for a height of 20 feet, are found. The figure is drawn on a large scale (80 feet to an inch), for the sake of clearness. It does not matter what scale we use for this purpose, provided that, in measuring the number of feet or yards in each horizontal equivalent, we use the same scale as that from which we have taken the height of 20 feet—that is, the distance between the parallel lines; but of course, in marking off any of these equivalents on our sketch, we must take the number of yards from the scale of the sketch, 6 inches to the mile, or whatever it may be.

This method of finding horizontal equivalents is better suited for purposes of illustration than for practical use. It requires very accurate drawing, and in the case of the gentler slopes the intersections with the upper line are so acute that it is difficult to determine them exactly. We can find the horizontal equivalent of any slope for any height readily and accurately by simple arithmetic.

The horizontal equivalent of 1° for 1 foot of height is 19·1 yards; for 2 feet of height it will of course be twice 19·1, for 3 feet three times, and so on, and therefore for 20 feet it will be $19{\cdot}1 \times 20 = 382$ yards. But a slope of 2° is twice as steep as a slope of 1°, *i.e.* we shall mount any given height in half the distance, therefore the horizontal equivalent of 2° for 20 feet is $\frac{382}{2} = 191$ yards; similarly for 3° it is $\frac{382}{3} = 127$ yards. Hence the simple rule,

$$\text{H E in yards} = \frac{19{\cdot}1 \times \text{height in feet}}{\text{slope in degrees}}.$$

This rule gives results quite exact enough for all practical

purposes. For the smaller angles the error is inappreciable; at 25° it is under one yard, at 35° about a yard and a half, after which it increases more rapidly.

This table of horizontal equivalents tells us how far we have to march on any of the named slopes, in order to reach a point 20 feet higher, or lower, than where we started from; or, rather, it gives us the distance between the two points, as it will appear on our sketch, *i.e.* the true horizontal distance, and not the length of the line which we actually pace along the sloping surface of the ground. It has been explained, however (Section III.), that on the gentler slopes, up to 5° or 6°, the difference between the two is so very small, being under 1 yard in 100, that we need not take it into account in contouring a military sketch. On steeper slopes, where the differences are greater, the same checks may be applied, from time to time, as we should use in sketching the details of the ground, and which have been already fully described.

It must be borne in mind that the method of contouring now being described is only approximate, and does not pretend to be quite exact. In fact, the instruments used, in military sketching, for measuring slopes, do not admit of their being ascertained to fractions of a degree, so that perfect accuracy is not to be expected.

It follows, as a practical result of what has been stated above, that, if we have means of measuring the slope of the ground along any selected line, we can, by pacing along that line, mark off a set of points on it, each 20 feet above or below the last, according as we are going up or down hill; and this is the principle on which the contouring of military sketches is executed.

A set of such lines is taken, each starting from the same level, and on each a series of points is marked off in the manner described. When a sufficient number of these has been obtained, the contours are traced by joining the corresponding points of the several series; that is, those which are on the same level with one another.

An instrument for measuring the angles of slopes is called

a 'Clinometer.' There are several different forms; but a very simple one, sufficient for purposes of military sketching, can be made (without adding to the number of instruments to be carried), by a thread, with a weight at the end of it, attached to the protractor. The thread is passed through the hole close to the centre mark, and secured by a loop. If the protractor is held perfectly level, with the inner edge uppermost, the thread, when stretched by the weight, will cover the line from the centre to the 90° mark; but if the protractor is inclined upwards or downwards, the thread will make an angle with this line, which can be read on the edge, by counting the number of degrees backwards or forwards, as the case may be, from 90° to where the thread hangs (Plate VII., *fig.* 25).

This angle is the same as the angle which the edge of the protractor makes with the horizontal line; that is to say, it gives the degree of slope at which it is held, and therefore, if it is held so that its edge is parallel with the surface of the ground, the angle shows the number of degrees in the slope.

To use this clinometer, the sketcher holds it in the right hand, near the eye, and looks along the upper edge at an object the height of his eye above the ground (Plate VII., *fig.* 25), thus keeping the edge parallel to the surface of the ground. The finger and thumb of the left hand are kept ready to press the thread against the lower edge when the weight is steady. The protractor should be held upright, so that the thread may slide easily against the surface. If it is allowed to swing away from it, the thumb, in closing on it, will probably move it to one side or other of its true position.

The angle is then read. If the thread is at 90°, the ground is level; but if to one side or the other, there is a slope, up or down, as the case may be, equal to the number of degrees counted from 90°.

This instrument can therefore be used as a level, as well as a clinometer, and its use is easy with a little practice. The chief drawback is, that in high wind it is difficult to get the weight steady. For this reason, a leaden bullet, being

heavier, is better than the small brass weight issued with the protractor, and the string should not be too long. If the weight hangs two or three inches below the protractor, it is sufficient.

Abney's reflecting level is sometimes used for measuring slopes. It consists of a small telescope tube, about $4\frac{1}{2}$ inches long, near one end of which is fixed, in a vertical position, a graduated semicircle of brass with teeth cut in the edge, and to which a small spirit level is attached, along, and parallel to, the diameter. The semicircle can be turned about on its centre by a screw with teeth fitting those of the edge, and the graduated part works along a small brass arc, with an index point in the middle. In the upper part of the telescope tube is a mirror, so arranged that, if we look through when the spirit level is horizontal, we see the bubble reflected.

To use the instrument for measuring slopes of ground, we set the 0° of the semicircle at the index, and look through the tube at an object the height of the eye above the ground. If the bubble is visible, the object is on our level; but if not, it is above or below us, and we must turn the screw slowly till we see the bubble. When we do so, the number of the degree opposite the index gives the angle of the slope.

This clinometer, like the other, is easy to use; but after some little experience in sketching, the eye becomes familiar with the slopes, and the clinometer need be but little used. It must be remembered, however, that the eye which is accustomed to judge slopes on turf may be deceived on heather, and *vice versâ*. It may also be remarked that it is much easier to distinguish, by the eye, the differences between the gentler slopes, than those between the steeper ones.

There may sometimes be difficulty in finding an object the height of the eye, to align the clinometer on. In enclosed country, something will generally offer itself. The top of a gatepost, or a point in a hedge, wall, or tree, may be taken. It does not matter how near, or how far off, the object is, provided that the slope of the ground is uniform throughout the distance. In an open country various ex-

pedients may be used. If two men are working together, one may march on to give a point to the other. Or a common walking stick may be set up, and a short distance paced up or down the slope, and then the angle taken kneeling, so as to bring the eye to the same height from the ground as the top of the stick. Or the sketcher may lie down and take his sight along the top of the grass, heather, or other growth. When, in going down hill, a gentler slope is succeeded by a steeper one (Plate VII., *fig.* 26), the sketcher may step back till the prolongation of the steeper slope meets the eye, and then align the clinometer along the surface of the ground.

It may be useful to remark that, the further off is the object looked at, the smaller will be the error caused by its not being exactly the height of the eye.

The protractor has a scale of horizontal equivalents on the back, by means of which their lengths can be marked off at once on the paper, instead of measuring them from the scale of yards. The length of each in yards is also given.

The way of using this scale is as follows: The sketcher, having chosen his line of march down hill, and laid it down on his paper, measures the angle of slope, ascertains from the protractor the number of yards in the horizontal equivalent, and starts to pace down the hill. He may either halt each time he completes the number of yards, and make a dot on his paper, or he may pace at once the whole distance to where the slope changes, mark his position on the paper, and put in at once, from the scale, as many equivalents as will go into the distance, commencing from the starting point, and marking each by a dot. Each dot will denote a fall of 20 feet.

Where the angle of slope changes, he must take a fresh observation with the clinometer, and proceed as before.

He may, if he pleases, number the dots 1, 2, 3, &c., commencing from the top, with small figures lightly pencilled, so as to make sure of joining the corresponding dots on the different lines correctly when he traces the contours.

It may happen that the distance to the change of slope is

not exactly divisible by the horizontal equivalent, but that there is a remainder after marking the last dot. This remainder, of course, represents a descent of a certain number of feet, after the last 20 foot stage was completed, which number is easily found, by comparing the number of yards in the remainder with the number in the whole equivalent.

Thus, if the remainder equals half the equivalent, the descent will have been 10 feet; if one-fifth of it, the descent will have been 4 feet. This must be taken account of in marking off the first contour on the next slope, which must of course be at the full vertical interval of 20 feet below the last contour. If it is 10 feet, only half the equivalent of the next slope must be paced before the next mark is made; if it is only 4 feet, four-fifths of the equivalent must be paced, and then the dot made.

An example will illustrate this. Suppose the slope at starting to be 3°, and that it continues for 190 yards. The equivalent of 3° is 127 yards, and the first dot is made at that distance. There is a remainder of 63 yards or half the equivalent, which denotes a fall of half of 20, *i.e.* 10 feet. The slope now changes to 6° and remains at this for 178 yards. The equivalent of 6° is 63 yards, but as half of the second 20 feet has been done already only half remains to do, therefore only half of the 63 yards, viz. 31, must be paced for the second dot. The third and fourth will be at the full intervals of 63 yards; that is, at 94 and 157 respectively from the change of slope. On reaching the 178 yards, where the next change of slope occurs, there is a remainder of 21 yards, which equals one-third of the equivalent, so that a descent of one-third of 20 feet has been made since the last contour. The slope now becomes 8°, the equivalent of which is 47 yards. As there are only two-thirds of 20 feet to go down to complete this stage, the fifth dot will be at 32 yards from the change, and the following ones at intervals of 47 yards, as long as the slope of 8° lasts.

The beginner may find it useful practice to work a few examples of this kind for himself, taking the slopes and number of yards in each at hazard.

For instance, let him place the dots for the contours on the following slopes, viz. 2° for 477 yards, 4° for 238 yards, 7° for 175 yards, and 10° for 142 yards.

He may easily set himself any number of examples of this kind, till he understands the principle thoroughly.

Contours are drawn in chain dotted lines, as shown in Plate VIII., and generally in blue or red to catch the eye. They are not drawn across roads or rivers, nor through houses, gravel pits, &c., but are dropped at one side, and continued again from the other. They are often numbered, as in the figure, to show their heights, in feet, above the level of the sea, or of the lowest point on the sketch.

It may be of use to caution the beginner against one or two mistakes, which are sometimes made, in forgetfulness of the true nature of contours.

A contour cannot be lost. It must either close on itself, as it does in going round an isolated hill, or continue unbroken till it reaches the limit of the sketch.

Nor can two contours run into one. To make them do so is to assert that two lines, one of which is always 20 feet above the other, are, at a certain point, on the same level, or that one of them is vertically over the other. This last fact, however, does really occur, in the exceptional case of an absolutely perpendicular precipice. This has no horizontal base; therefore, strictly speaking,* the top and bottom, and, consequently, all the intermediate contours, would run into a single line. But when the cliff changes again to hill side, the lost contours will reappear in their proper places.

It is not safe to trace a contour joining two points, though ascertained to be on the same level, unless the intervening ground can be seen. We cannot tell how the contour may wind, in passing from one point to the other, nor, in fact, whether they ought to be joined at all.

For instance, the points *a a* in Plate VIII. are on the same level; yet it would be an error to join them, for there is lower ground between, and a contour cannot depart, even for the shortest distance, from its own proper level.

* To represent the cliff on paper a certain width must be taken.

When, as is generally the case, the top of a hill is higher than the highest contour, it should be numbered with its total height, in feet, above the lowest point of the sketch.

SECTION XII.

PRACTICAL CONTOURING.

The object of the last two sections has been to prepare the learner for the operation of systematically contouring a piece of ground.

But before he can satisfactorily carry out the details of this work, it is essential that he should have grasped the *general idea* of the way in which ground is represented by contours; that is to say, he should understand how they wind round a spur or valley, in what directions they bend to mark a salient, or a re-entrant, how they are situated on a saddle, &c.

To master this is perhaps the most difficult part of military sketching to a beginner, especially without the aid of an instructor. Something may be done towards it by comparing contoured sketches and models of the same ground. Still more may be learnt by going over a piece of ground, with a contoured sketch of the same in hand, comparing the natural features with their representations on the paper, and endeavouring to trace the course of any particular contour. As a further step, the learner may sketch for himself the details of any piece of hilly ground, the features of which are well defined, and, taking it to the ground with him, try to follow the contours by the eye. In doing this, the question he has continually to ask himself is this: 'In what direction must I walk to keep on my present level?' The answer to this is the solution of the problem. When he can in this way run a single contour through his sketch, he may, by observing the slopes up and down, trace the contours next above and below it, and thus, by degrees, establish in his mind a conception of the relation between real ground and the contours representing it.

During the process of triangulating and putting in the details of a piece of ground, some knowledge of the nature of its features will have been gained ; sufficient, in the case of a sketcher who knows his business, to enable a decision to be come to, as to the best and most expeditious way of executing the contouring.

Ground is so infinitely varied in its combinations, that it is scarcely possible to do more than give a few general rules for guidance. The details of the execution of each individual case must be left to the judgment of the sketcher.

As a general rule, the contouring of a piece of ground is commenced by sketching in the 'crest line,' or highest contour, which serves as a starting point for running the several lines down hill, as described in the last section.

This is done by traversing, using the clinometer as a level.

There are certain advantages in commencing with the crest line. Besides its being shorter to traverse than the lower contours, the ground is usually more open and free from enclosures and other hindrances to traversing at the top than at the bottom of a hill. Besides this, a better general view of the shape of the ground is obtained, which is useful to the sketcher as enabling him the better to decide on his plan of subsequent operations.

On some kinds of ground, the tops of the hills are level plateaux, with well marked crest lines, from which the ground begins distinctly to fall. More frequently, however, there is no well defined crest line, and the sketcher must decide on the level at which he will trace his highest contour. This must, of course, not be more than 20 feet* below the summit, or another contour would have to be drawn above it.

The chief points to be considered, in deciding on the crest line, are, that it should give a good general indication of the shape of the top of the hill, and that there should be points on it which can be found again (such as gates, conspicuous

* We are supposing the sketch to be at 6 inches to the mile, with 20 feet vertical intervals.

trees or bushes, rocks, &c.), so that the sketcher may, without difficulty, establish himself on the proper level, on his return to the top, after each journey down the hill.

Having fixed on his line, he finds, by means of the clinometer,* some point, at a convenient distance from him, on his own level, and traverses up to it, putting in the bends of the crest line as he goes. When these are small and unimportant, they may be put in by the eye, remembering that when the line of pacing passes over a slight rise, the crest line curves outward, *i.e.* away from the summit, while, in the case of a dip, it curves towards the summit. But when the bends of the crest line are considerable, so as to affect to any extent the shape of the lower ground, offsets must be paced, and the levels checked by the clinometer. It is important to get the heads of the salients and re-entrants correctly placed, for they mark out the shape of the ground, and form the starting points of the several lines which are run down the hill.

The remainder of the crest line is traced in the same way, by levelling and traversing, till it either closes on the starting point, or reaches the limit of the ground which it is intended to sketch.

Having completed the crest line, the sketcher commences to work down the slopes, along such lines as he considers necessary, in order to obtain, in the manner already explained, the several series of points (at 20 feet vertical intervals), which are required to enable him to trace the successive contours below the crest line.

These lines need not necessarily be numerous. As a rule a few, judiciously chosen, will suffice; they should, whenever it is practicable, cut each contour at right angles,† as the

* For short distances, levels may be judged pretty accurately by the eye, with practice; but at long distances the eye is deceived. A long stretch of intervening ground generally makes the distant point look higher than it really is.

† Where the contours are straight, and parallel to one another, as along a straight hill side, it is easy to conceive a line drawn at right angles to them. But where they are curved, this may require explana-

shape of the ground is more correctly indicated by joining the points thus obtained, than if the contours are cut obliquely. Lines traced in this way, cutting every contour they meet at right angles, are called 'orthogonals.'

It may, in some cases, be necessary to run an orthogonal down the side of a hill or spur; but the principal lines to be followed are the watershed and watercourse lines, as it is on them that the contours turn to change their directions.

The watercourse lines are distinctly marked on the ground, and it is easy to follow them. The watershed lines are not so easy, and it may often require a practised eye to recognise them. A rough rule may be given for following the watershed line down any spur or bulge of ground, viz. always to aim at where the ground appears to come to a point, *i.e.* in the direction in which the lower ground appears furthest from us. By continually doing this, we shall always be passing through the points on which the contours turn, which is what we want to do.

It may help the learner to understand this, if he studies a plaster model of ground, and endeavours to trace the watershed lines. He will find that these, as well as the watercourses, cut each successive contour at right angles at the extremity of its bend.

These watershed lines are not always straight. Very often they are curved, and sometimes are very irregular in their course. To traverse them systematically would take a long time; but in a sketch of which the details are already drawn, the sketcher will often find himself marching in the direction of some known point, or nearly in such direction, so that great part of the orthogonals may generally be traced by the eye, without much use of the compass. Provided the position is occasionally checked by an interpolation, an error of a few yards to the right or left, in tracing the intermediate parts, will affect the shape of the ground but little, if at all.

tion. A straight line is said to cut a curve at right angles in any point, when it is at right angles to a straight line drawn touching the curve at that point.

To pace the whole slope, from the highest to the lowest level on every line, would be very laborious. In many cases it is not necessary to do so. When we see that a slope is uniform down to any point, whose position is marked on our paper, we can find, by the scale, the number of equivalents that will go into the distance, and mark them off, without pacing it. For instance, when, at the foot of the slope, there is a creek, lake, or marsh, the edges of which are correctly marked on the sketch, we may stop our pacing down, as soon as we reach a point from which the slope continues to the bottom without change. By taking the angle of this slope, and marking down the equivalents from the scale, as many as will fit into the distance, we get the proper number of contours, and consequently know the height of the hill.

We can do the same though the slope be not uniform, provided we can see the ground the whole way to the bottom. This will be the case when the ground is concave in section, *i.e.* when the upper part of the slope is steeper than the lower (Plate VII., *fig.* 27). In this case, we measure the average slope (A to C), and if we know the distance to the bottom, we know how many contours there must be, and can insert the right number. We must, however, take care to place the upper contours closer together than the lower ones, so as to show that there is a change of slope. We can generally do this correctly enough by judgment, but, if we wish to be more accurate, we can measure the angle of the upper slope (A to B), so as to find exactly how close together the contours nearest to us should be placed, and then distribute the remaining contours through the rest of the distance.

Again, though, in some cases, we may have to run orthogonals up or down the watercourse of a valley, in order to ascertain its fall, we can often save the labour of doing so. For instance, when we work down different re-entrants, all leading into a principal watercourse, we find the level of the latter at each point where we strike it, and, by observing the slope of its bed up and down each time, we can generally put in the intermediate contours, without pacing up or down it; which, in fact, would often be difficult to do.

On the same principle, when we have a spur between two watercourses, it will generally be sufficient to measure the slopes of the latter from their heads, and, judging how far those slopes continue without change, to dot in the contours accordingly, and then to run an orthogonal down the spur to where the watercourses meet. We can then measure their slopes upwards, as far as we can see; and, as we know, from having worked down the spur, the total number of contours from top to bottom, we can generally put in the intermediate ones, along the streams, with sufficient correctness. If the spur is a very long one, we may, if we please, at any point of it (marking our position so as to be able to find it again), run an orthogonal down the side into the bed of either watercourse, or both, which will give us the level of each where we strike it. By doing this, we are also able to observe whether the sides of the spur have any salients or re-entrants which we ought to notice.

It often happens that a re-entrant, which is strongly marked at the crest line, becomes less and less so as we go down it, till at last its contours blend into those of the lower slopes of the hill. It is unnecessary to follow it beyond this point.

In sketching a valley with hills on each side, it is useful, while working down one side into the valley, to take opportunities of levelling across, with the clinometer, to known points on the opposite side. This establishes a correspondence of levels between the two, which, if not more accurate, serves, at all events, as a check on those obtained by working down one side and up the other. If the hedgerows and similar landmarks are down on our sketch, we may sometimes be able to trace a whole contour, by observing what points in the hedges, &c. are on our level, both on the sides and towards the head of the valley. We can then take their bearings with the compass, and join the points at which those bearings cut the several hedges respectively.

We may find, approximately, the angle of a slope at a distance from us, if we can see its edge well marked against the sky, or any other good background, by holding up the

clinometer across us, so that its upper edge coincides with the surface of the slope, and reading the angle.

It is not necessary invariably to begin the contouring of a piece of ground from the highest part. The crest line must, of course, be sketched; but, instead of beginning with it, we may first work up to it, by running an orthogonal up from some lower level, either the lowest on our ground, or some intermediate one.

For instance, we may start from some point near the end of a spur, contour the lower part of it first, and then work up its watershed to the crest.

Or if a large valley forms one of the principal features on our ground, we may start from the bottom, and work up it till we reach the crest, taking the slopes of the sides as we go, and marking in the various salients, re-entrants, and minor watercourses. On reaching the crest line, we can proceed, in the manner already described, to finish the ground.

This would be the course to adopt if the contours had to be placed at fixed vertical intervals counted upwards from any given zero level. In such case there is no choice as to the position of the top contour, as its height in feet above the zero level must be an exact multiple of the vertical interval, and we must find the right position for it before commencing to trace it.

When the sea is the given zero level, we may possibly find on our ground bench marks * which we can make use of. If we have one of these at or near the top of the hill, we can at once place the highest contour. If, instead of the top, there is one at or about half way up, we may either, by means of it, run an intermediate contour round the hill, and work upwards and downwards from it, or run a section line from the bench mark to the top, and proceed as already described.

In fact, there are many different ways of contouring a piece of ground, and a sketcher must judge for himself

* A bench mark is a point whose height above the sea has been ascertained and permanently marked.

which to adopt. To guide him in this, he should endeavour to gain all the knowledge he can of his ground while executing the preliminary parts of his sketch.

SECTION XIII.

EXECUTION AND FINISHING OF THE SKETCH.

Besides compass and protractor, the requisites for sketching in the field are as follows, viz. sketching case, pencils, india-rubber, penknife, and note book.

The foundation of the sketching case must be a smooth stiff surface, such as millboard, to stretch the paper on, with some means of fastening it down, either elastic bands, or, better still, a metal rim, about half an inch wide, going all round the edge, so as to clip the sides of the paper down, opening and closing on the millboard by a leather hinge on one side, and kept tight by a strap and buckle on the other. This is the principle of the sketching case used at the Royal Military College. It has the advantage of allowing the spare edges of the paper to be folded under, which is useful where a large sketch has to be made. There is also a waterproof flap to protect the sketch from rain, dirt, &c., and a strap to hang the case over the shoulders.

The pencils required are a hard (HHH) and a softer one (HB), and blue and red chalk pencils, the former to put in water, and the latter masonry buildings, bridges, &c.

For all the plotting of the sketch, the hard pencil is used, with a very fine point, and all the work is done lightly, so as to be easily rubbed out where corrections are necessary. All superfluous lines and dots should be taken out at once. When all the work on the ground is done, and the sketcher satisfied of its correctness, the soft dark pencil comes into use, all the lines being gone over with it, so as to bring them out clear and distinct. In doing this, the original work may be rubbed out, bit by bit, so as to be only just visible, before tracing it over with the dark pencil, so that all errors

and confused parts may disappear, and only the correct work be seen.

The sketch is then fit to be handed in on the ground, if required; but in all cases, whether given in in pencil, or subsequently inked in, the scale,* and north point, must be drawn (as shown in Plate I., *figs.* 2 and 6), in some convenient part of the paper, the vertical interval between contours noted, and the sketch signed, dated, and headed with the name of the locality.

Also the names of all places on the sketch, and of those to, and from, which the roads lead, must be clearly written or printed.

If the sketch is to be inked in, indian ink is used. Where any colour is to be laid on, as on roads, woods, &c., all pencilling under the colour should be entirely rubbed out first, as it will not come out afterwards. If edges of roads or rivers, or boundaries of woods, are inked before the colour is laid on, they should be done in very fine lines, lest the ink should run. They can be thickened, if required, when the paint is dry.

In laying on a flat shade, enough paint for the whole should be mixed at once, as it is difficult to get the same shade again. The colour should be laid on quickly, and the edge not allowed to get dry till the whole is done.

When the triangulation has to be shown in a sketch, it is generally done in red, the base line being drawn slightly thicker than the others.

It is well to bear in mind always, that, next to accuracy, clearness is the most valuable quality in a military sketch.

SECTION XIV.

SHADING.

The features of ground may be represented by shading with pen, pencil, or brush, either instead of, or in addition to,

* The scale is easily drawn by ticking off the lengths of the divisions from the edge of the protractor.

the contours. The former is not an accurate method, and the shading is more frequently used to complete the sketch after the contours have been drawn, than as a substitute for them. In either case the principle is the same, viz. to bring out the steep slopes by strong dark shading, to shade the gentler slopes more lightly, and to leave the level ground white.

The object of shading is to bring prominently before the eye the relative steepness of slopes, and to show changes of ground which escape the contours. To gain the latter object, it is necessary (unless the shading is done on the ground) to note these small variations by lightly pencilled contours at half or quarter intervals, or in some similar way.

Various systems of shading have been in use at different times in the service, but only two need be noticed here, viz. the 'horizontal system,' and shading with black lead and stump. The former of these has by recent orders been almost entirely superseded by the latter, but, as it may still be used by officers who have an aptitude for it, it is desirable that its principles should be understood, so far at least as to make a sketch shaded on this system intelligible.

Horizontal shading is executed by drawing small strokes (called hachures), between the contours, conforming to their bends and approximately parallel to them. In order that slopes of the same steepness may always be shaded uniformly, a 'scale of shade' has been established, regulating the thickness and distance apart of the hachures indicating particular slopes,* the darker shades being produced both by thickening each stroke, and by drawing the strokes closer together. This scale does not vary with the scale of the map, its principle being that for each slope there shall be a certain number of strokes per inch, and each stroke of a given thickness.

These hachures in some respects resemble intermediate

* The slopes provided for in the scale are 2°, 3°, 5°, 10°, 15°, 20°, 25°, 35°. Intermediate slopes, as well as those under 2° and over 35°, are left to the judgment of the draftsman. Slopes over 45° are shown as broken ground.

contours, but there are some essential points of difference. There are more strokes between contours on gentle than on steep slopes, owing to the contours being so much further apart, consequently each hachure does not represent a fixed value in vertical height, as each contour does. It follows from this that the hachures cannot be drawn continuously, as, in passing from one slope to another, strokes have to be dropped, or additional ones inserted. To do this neatly is not easy. In fact, to hachure well requires skill which few possess naturally and many can never acquire ; and this, with the time and labour it requires, makes it unsuitable for general use in military sketching.

The other system alluded to, viz. shading with black lead and stump, which has been lately adopted for the service, is far simpler and more expeditious, and has the great advantage that anyone can learn to execute it at all events tolerably. The process is simple. A little black lead from a pencil is scraped on to the paper, and rubbed in with a stump or a bit of chamois leather, so as to produce a pale uniform tint, the flat tops of hills being kept white. A little more black lead is then powdered over the drawing, omitting the gentlest slopes, and rubbed in as before, the edges of this shade being toned off by the stump into the paler part. This is repeated as often as necessary, so as to produce a gradation of shades from the gentlest to the steepest parts, the edges being always blended into each other, so that there may be no sharply cut lines between the different shades. The strongly marked watershed lines are made to stand out by passing india-rubber along them, softening off the edges of the pale lines thus produced into the darker shades on each side. By alternate use of india-rubber and stump, any required degree of prominence may be given to the parts which should stand out. The watercourses are traced in a somewhat similar way, so as to be shown by a slightly paler line between the dark slopes on either side.

A scale of shade for this system has been published, and can be obtained from any of the Military booksellers.

Shading is not absolutely necessary. A correctly con-

toured sketch shows the heights of hills, and the steepness of the slopes, which are the essential points for military purposes. A military draftsman must, however, understand enough of the principles of shading to be able to read a shaded sketch.

Shading should not obliterate the contours. The latter should, therefore, be drawn so as to be seen through it, and the heights of the tops of the hills should also be marked.

SECTION XV.

READING MAPS.

To be able to 'read' a military map, that is, to obtain from it all the information which it is intended to convey, so as to make practical use of it, is at least as necessary as to be able to make one, and the learning to do so forms part of the course of instruction to be gone through by every officer.*

To understand and to make practical use of a map without contours is an easy matter. Some common sense, a little practice, and a knowledge of the conventional signs used to represent the various objects, are all that is required. But with contoured maps the case is quite different.

To recognise at once the general shape of a large piece of ground from a contoured sketch of it is difficult, especially when the ground is undulating and the features not strongly marked.

The power of doing so is only to be gained by practice. Something may be done towards it by study of maps in which the contours are marked with their heights in feet, or again by comparing together models and contoured sketches of the same ground. But, just as in reading a book in a foreign language, we must find out the meaning of the words com-

* 'Every officer should be prepared to report on the country passed over by a line drawn on a good military map, and to detail what he would see if he stood at any spot on the ground marked by a point on the map' (*Queen's Regulations*, App. II. p. 390).

posing a sentence before the sentence itself will convey any idea to our minds, so we must learn to recognise the meanings of the several groups of contours which denote the various features of ground before we can comprehend the combination of them as a whole.

The first step towards reading a contoured map is to be able to discover which of any two adjacent contours is the higher. Without this we cannot distinguish with certainty between a spur and a valley (which are often very much alike in their outlines on paper), nor can we determine the relative commands of different points, nor whether in travelling along any given line we are going up or down hill. If sea, lake, or river are present on the map, we know that the contour nearest to the water is lower than its next neighbour, and, following this up, that if we draw a line straight away from the water, each contour crossed is higher than the last. This rise will, however, cease when the line, after crossing any contour, returns to it again. This indicates that we have crossed a watershed line, and that a fall begins. Whenever streams appear on a sketch, they serve at once to distinguish watercourses from watersheds, and consequently spurs from valleys. The direction in which the streams run is generally indicated by arrows, but even if this is not the case, we can tell it by the bends of the contours that turn on any stream, as the water must always run *out of* and not *into* these bends. Of course in going up a stream, each contour we cross is higher than the preceding one. Another means of determining the relative heights of adjacent contours is often available. A contour whose ends meet denotes the top of a hill or knoll, and if there be more than one such, the inner is the higher. If we draw a line away from the top of a hill, each contour that it crosses will be lower than the last, but the rule given above, or rather the converse of it, holds good here also: the fall ceases and a rise begins when the line cuts the same contour twice, as a dip or watercourse has then been crossed.

By the above rules the rise or fall of ground along any given line is easily determined. The relative heights of any

two points are readily found by counting contours downwards to each from the top of the nearest hill or upwards to each from the water's edge, or from the nearest contour embracing the two, whichever may be most convenient.

In crossing a saddle, a change also occurs from fall to rise or rise to fall, according to the direction in which we cross it. This appears at first sight to be an exception to the rule above given, but is in reality only a particular case of it. A saddle (*see* Plate VIII.) is denoted by two pairs of opposite contours, which approach one another, but leave a space between; each pair of opposite contours being on the same level with one another, but one pair being lower than the other. In this case, therefore, the line on which the change occurs does not actually cross the same contour twice, but crosses in succession two which are on the same level, and the effect is the same. Very little practice in reading contours is required to recognise a saddle at once from its shape.

One or two simple examples to illustrate the above rules may be of use.

1. To find the highest and lowest contours in the map, Plate IX. Working up the watercourse on the left of the map, we find that the highest contour which crosses the stream is at A; if, then, we draw a line in the direction A B, there must be a rise the whole way, as the line is drawn away from the water and does not cross the same contour twice; evidently there can be no higher contour on the map than that on which B is. The lowest contour on the map will plainly be on one of the watercourses. Counting downwards from B, we find that the contour at D is the ninth below it, while that at C is the tenth; the latter is therefore the lowest in the map. It must be remembered that this is a very simple case. In a larger and more intricate map, we may have to make several trials on different watercourses, establishing a correspondence of levels between them by following some convenient contour round from one to the other, and counting upwards from each, so as to make sure of reaching the highest.

2. Given a line from E to F, to determine the rise and fall along it. Starting from E, there must be a fall as we approach the water, and a rise after we have passed it (the same contour having been crossed twice), which rise continues till we again cross the same contour twice at *e* and *e*, the highest point being about midway between them. There is then a fall to the watercourse changing to a rise on crossing it, which again changes to fall between *f* and *f*.

The steepness of slopes as affecting movements of troops * is another important point shown by contours. It is clear from what has been said in Section XI. that not only is the relative steepness of slopes shown, but the absolute steepness of any slope can be found by measuring perpendicularly across from contour to contour, and comparing the distance with the table of horizontal equivalents. It will generally be the case that, where slopes are too steep to be ascended direct, they can be surmounted by moving obliquely, and an approximate line of road, with any given maximum gradient, can be traced on a contoured map by setting the dividers to the horizontal equivalent of the given gradient, and stepping them across from contour to contour. Where the contours are further apart than this, there will be some latitude in choice of direction, and advantage should be taken of this to reach favourable points for mounting the steeper slopes in as direct a line and with as few turns as possible.

We can also to a certain extent determine, by means of contours, whether one point on the ground can be seen from another; to a certain extent only, for gorse, brushwood, or other accidents may come in the way; all that the contours tell us is whether the ground itself is likely to intercept the view.

A simple general rule may be laid down for all such

* These slopes are given in the *Aide Mémoire* as follows:—

60° Impracticable for infantry.
45° Difficult for do.
30° Impracticable for cavalry.
15° Do. for guns.
5° Good manœuvring ground for all arms.

cases. If the ground between the points is convex in section they cannot be seen from one another; if it is concave they can. If the points are on the same level, we can ascertain this by drawing a line from one to the other, and noting whether the ground it passes over is higher or lower than the points. For instance, suppose picket sentries to be posted at a_1, a_2, a_3 (Plate IX.), they would probably not be able to see each other, as the lines joining them pass over higher ground, *i.e.* they pass between the contour on which a_1, a_2, a_3 are, and the next higher one, and the section is convex. But if the same sentries are posted at b_1, b_2, b_3, the lines joining them pass entirely over lower ground, *i.e.* the section is concave, and they will almost certainly see each other.

If the points are not on the same level the rule still holds good, but the determination has to be arrived at in a somewhat different manner. A glance at *figs.* 26 and 27, Plate VII., will show that when a gentle slope at the top of a hill is succeeded by a steep one lower down, a convex section is formed, but when the steep slope is near the top and the gentler one below, the section is concave. The distances of the contours from one another show the relative steepness of the slopes, and we must compare these in succession from the top downwards. For example, suppose a man to be standing at B and looking southwards. He will certainly see the ground as far as h, for the slope from B to b_1 is steeper than that from b_1 to k, which again is steeper than that from k to h. As far as h therefore the section is concave. From h to m the slope is steeper than from k to h, and it would appear at first sight that m cannot be seen from B. But to determine this we must compare the *average* slope from B to h (or more strictly speaking, the slope of a line from the eye of the man at B to the point h), with the slope from h to m, so as to ascertain which is the steeper. h is 60 feet lower than B, and 1,000 yards from it; therefore, taking the eye at 5 feet from the ground, the slope of the line of sight is 65 feet in 1,000 yards, or 1 foot in 15·4 yards nearly; m is 20 feet lower than h and 360 yards from it; the slope therefore

is 20 feet in 360 yards, or 1 foot in 18 yards, being less steep than that from *b* to *h*. The outline is therefore concave, and the view from B to *m* is not intercepted by the ground at *h*; or, in other words, the line of sight from B to *h* produced would pass *below m*.

The above example is one of the simplest of its kind, the points being all on the same feature of the ground and on its watershed line. To take an instance of a less simple character, suppose it is required to ascertain whether a man at P could see the ground at *p*. It is evident at a glance that the steep fall from *s* to the watercourse, succeeding the gentle one from P to *s*, will hide from view a considerable extent of ground beyond *s*, but after passing the watercourse there is a slight rise which may bring the ground at *p* into view. From P to *s* the distance is 700 yards, and the difference of level (taking as before the eye at 5 feet above ground) is 25 feet. The slope is then 25 feet in 700 yards, or 1 foot in 28 yards; *p* is 1,400 yards from *s* and 60 feet lower, being a slope of 1 foot in about 23 yards. This is of course steeper than 1 foot in 28 yards, so that the section is convex, and *p* not seen from P.

It is possible that though a man at P cannot see the ground at *p*, he might see a man standing up there. To find out if this is the case, we must produce the line of sight from P through *s*, and see how near to the ground it is at *p*. The total distance from P to *p* is 2,100 yards; and as the line of sight slopes downwards 25 feet in 700 yards it will fall 75 feet in 2,100 yards. But the ground at *p* is 85 feet lower than the observer's eye, so that an object at *p* must be at least 10 feet high to be seen from P.

It will be observed that it is not necessary to take into account intermediate changes of ground between *s* and *p*, all that is required being the actual difference of level between the two points.

All problems of this kind can be worked out in a similar way; the only difficulty being to determine the point of ground on which the question turns, *i.e.* on either side of which the slopes have to be compared. To do so readily requires

some practice. It may be remarked that, as a rule, points on the watersheds of adjacent features are visible from one another, and the ground immediately beyond them screened from view if the points are anywhere near the same level.

Another practical use that may be made of a contoured map is to ascertain how far back from the edge of a plateau guns may be placed so as to fire down the slopes with a minimum of exposure to the enemy's fire; or, again, how far back from the edge a picket sentry can stand so as to see without being seen, or other questions of a similar kind. To determine these we have only to find the point at which the line of slope of the ground produced upwards would meet the muzzle of the gun or the sentry's eye. Thus, supposing guns posted at B to fire on *h*. The slope from B to *h* is 60 feet in 1,000 yards. This is equivalent to $3\frac{1}{2}$ feet (the height of the muzzle of a field gun) in $58\frac{1}{3}$ yards; so that the guns could go back about 58 yards from the edge, and still be able to fire on *h*.

SECTION XVI.

DRAWING SECTIONS OF GROUND.

If we suppose a hill to be cut vertically downwards into two parts, and the part on one side of the cut removed, there will be exposed to view an outline of the surface of the ground along the line of the cut, showing its rise and fall, the steepness of the slopes, and the heights of the several points along that line. Such an outline is called a 'section' of the hill: a section of ground being defined as 'the intersection of its surface with a vertical plane.'

On a contoured map of ground, we may draw a straight line in any direction, cutting the contours, as A B (Plate X., *fig.* 28), and, if we know the scale of the map, and the vertical interval between the contours, a section of the ground on that line can be drawn as follows:

A certain level must first be assumed, from which to

measure the heights of the several points in which the line cuts the contours. This is called the 'datum level,' and may be assumed at the level of the lowest contour, or at any lower level that may be convenient, such as that of the sea, or any large sheet of water on the ground.

A line is drawn to represent this 'datum level,' and above it, parallel to it, lines are drawn at distances apart (by the scale of the map), equal to the vertical interval between the contours. As many of these lines must be drawn as there are contours.*

The next step is to measure on the plan, along the cutting line, the distances of the several points in which it cuts the contours, and to transfer them to the datum line. This is readily done by laying a straight edge of paper along the former line, marking the intersections, and then taking them off along the latter line.

At each of these points perpendiculars are raised. These, with the parallel lines already drawn, will form a set of rectangles (see Plate X., *fig.* 28), and the section can then be drawn, by following the cutting line through its successive intersections with the contours, marking the height of each above the datum level on the corresponding perpendicular, and then tracing a line through these points.

The lines joining the points will, in general, be diagonals to the rectangles, drawn upwards where the ground rises, and downwards where it falls; but in some cases, in passing from one intersection to another, they will rise or dip slightly and return to the same level.

In the example given, the lowest contour is taken as the datum level, and the ground rises through the first five intersections, reaching the fifth contour from the lowest. The section line then passes over the top of the hill, and returns to the fifth contour. In the next two stages there is a fall from the fifth to the third contour above the datum level. Next, the line dips, nearly, but not quite, touching the

* Of course if the datum level is below the lowest contour, the first of the parallels must be drawn at a distance above the datum line equal to the difference.

second contour, and rises again to the third. It then rises very slightly above the third, and returns to it again, and then falls through the next three stages till it arrives at the datum level.

In this example, the contours are numbered along the line A B, to facilitate following it out, the datum level being numbered 0, the next above it 1, and so on. Corresponding numbers are put to the parallels drawn above the datum line. This precaution may be taken to prevent mistakes when a section of complicated ground has to be drawn.

In inking in a section, it is usual to draw the datum and section lines continuous, and those parts of the parallels and perpendiculars, which lie between them, dotted, and to rub out the rest. In the example, the whole of the latter are left, to show the construction.

If, in drawing a section of ground, the heights of the perpendiculars are measured by the same scale as that to which the map is drawn, the section is a true one. But this does not convey an adequate idea of the steepness of the slopes, and it is common to exaggerate the vertical heights in proportion to the horizontal distances. In the example, the former have been exaggerated by three times—a convenient proportion, as the scale of yards, used in measuring distances, can be taken as a scale of feet for the heights.

A handy way, in this case, of getting the distances for the parallels, is to raise perpendiculars near the ends of the datum line, and to mark off on each of them, from the scale on the protractor, as many distances of 20 feet as are required, and then to join the points.

SECTION XVII.

COPYING, REDUCING, AND ENLARGING MAPS.

One of the simplest ways of making a copy of a military sketch is to lay over it a piece of tracing paper, or cloth, made for the purpose, through which everything can be seen, and to trace over it, in pencil, all the lines, &c. of the

original. This is an expeditious way of copying, and the original is not defaced. If the work is interrupted before completion, it can be resumed at any time, as the tracing material can be replaced in its proper position on the map by means of the lines already drawn.

If the copy is required to be kept for any length of time, cloth is preferable to paper, as the latter is fragile, nor is it easy to ink in the drawing on it.

A copy may be made on ordinary drawing paper on the same principle; but, instead of laying it over the original on a table, both are held up against the glass of a window, when, if the lines on the original are distinctly drawn, they can be seen through by means of the light at the back. If they are too faint for this, a trace can be made on thin paper, (as described in the last paragraph), with strong dark lines, and the copy made from this by holding it to the window. This is an inconvenient method when the map to be copied is large.

Copies may also be made by means of black lead tracing paper. This is laid on the clean paper (blackened side downwards), and the original on the top of all. The lines in the latter are then gone over with some blunt pointed instrument, slight pressure being applied, so as to transfer all the lines to the paper underneath. A disadvantage of this method is, that, if the work is interrupted in the middle, it is difficult to replace the sheets exactly as before; and if the copier should accidentally omit to go over any of the lines, he does not know it till the paper is taken up. Also the original is defaced to some extent; but this may be avoided by first taking a trace on thin paper, and using it to make the copy from.

Another way of copying a map is to rule lines dividing it (or a trace of it, if the original must not be defaced) into squares of a convenient size, and to rule similar squares on the paper on which the copy is to be made. The details are then copied, square by square, by marking the points where roads, streams, boundaries, &c. cut the sides, and joining them, drawing any intermediate bends by eye, or measuring

offsets to them from two adjacent sides of the square. If there is very much detail in a square, the diagonals may be drawn to help. The exact position of any important landmark, such as a church, cross roads, &c., may be got by measuring its distance from two corners of the square in which it is, and describing arcs to intersect one another from the corresponding corners in the copy.

This is not an expeditious method; but very accurate copies may be made by it, and the principle may be usefully applied, where the copy is required to be on a larger or smaller scale than the original, by ruling the squares larger, or smaller, in the required proportion.

For example, a plan, at 6 inches to the mile, has to be copied on a scale of 3 inches to the mile. Rule the original in squares of 1 inch side (Plate X., *fig.* 29), and the paper for the copy in squares of half an inch side, and copy square by square, of course halving, on the copy, all the distances measured on the original. By reversing the process, a copy on double the scale of the original may be made. In the same way, copies may be made on a scale three, four, five, &c. times larger or smaller than the original, by proportioning the size of the squares accordingly.

In the case referred to in Section VII., where a considerable length of road has to be sketched, a trace of it may be made before starting, from a map of the country, by the above means, whatever may be the scale of the map and of the proposed sketch.

The proportion between the sides of the squares is easily found by means of the representative fractions.

To give an instance: Suppose it is required to make a trace on a scale of 2 inches to a mile, or $\frac{1}{31680}$, from an Italian Government map, of which the scale is $\frac{1}{86400}$. The simplest way will be to make the squares for the sketch of 1 inch side. As this length represents half a mile, we must find what length of line on the Italian map represents that distance. By the rule given on page 8, $\frac{63360}{86400} = 0{\cdot}733$, therefore the Italian map is on a scale of 0·733 inches to a mile. 0·37 inches will then represent half a mile, and we must

make the sides of the squares on the original that length. We should require a scale of yards at $\frac{1}{86400}$ for measuring distances on the original, and one of 2 inches to a mile for transferring them to the copy.

If the trace when made is to be corrected on the ground by the prismatic compass, we want North and South lines to plot our bearings by. As the true and not the magnetic North is shown on geographical maps, we must find the local variation, so as to be able to draw the magnetic North and South lines. This is done as follows: Choose two well defined landmarks on the ground, and take the bearing of one from the other. Draw a line on the map joining them, and lay the protractor so that the centre mark and the observed bearing may both be on this line. The edge will then be in the direction of magnetic North and South, and we can rule the sides of the squares both on original and copy parallel to and perpendicular to it.

PART II.

RECONNAISSANCE.

INTRODUCTORY.

This manual is designed for the use of Regimental Officers, giving suggestions for progressive instruction in reconnoitring ground.

At page 108 will be found notes for the instruction of non-commissioned officers of Cavalry, Infantry, and Artillery.

A Military reconnaissance means the process of obtaining information respecting, 1st, the enemy; 2nd, the country in which military operations are to take place.

The more important reconnaissances would probably be carried out by staff officers, but every officer should be able to take at least a subordinate part in this work.

Reconnaissances of *the enemy*, and reconnaissances 'in force,' will be treated under the head of Tactics in another manual.

This treatise will deal only with the duty of reconnoitring *the country*.

Part I. explains how to make a military sketch; Part II. will show how to apply this knowledge practically, for the requirements of war.

On service Commissariat officers, and others specially selected, would probably gather information about 'sup-

plies;' a few notes, however, upon this subject and 'accommodation' are given in pages 106–7 for the use of combatant officers employed on this duty.

SECTION I.

TOPOGRAPHICAL RECONNAISSANCES.

It is not generally necessary for an officer to sketch the whole of the country that he is to reconnoitre—there may not be time for this in war. But it is essential that he be competent to sketch, to enable him to give details, and the principal points of his reconnaissance.

To abridge this operation, before proceeding to the ground, he can, from a correct map of the country, fix the situations of towns and villages, roads and large rivers, on a scale susceptible of details, and afterwards sketch in the ground while passing over it.

Existing maps to be utilised.—In the present day maps of most civilised countries are procurable; these might be rapidly multiplied on an enlarged scale by means of photozincography, or some other process, and as many copies as required issued to the troops.

But maps merely enlarged give no fuller information than before; all further details must be put in on the ground by the reconnoitrer.

Many old maps and some new ones cannot be trusted. Hills remain unaltered, but rivers do not; marshes disappear, old woods are cut down and new ones spring up; railways, villages, and roads come into existence or change their character, and hence it becomes necessary to test the accuracy of existing maps before depending upon them, as incorrect information purporting to be true is often worse than none.

Maps to be tested.—A map may be tested thus: Draw three or four straight lines across its face at random. Observe what features (hills, woods, bridges, cross roads, villages, &c.) each line cuts through, and compare these with

what you actually observe on the ground. If a map stands this test its general character is usually correct.

Necessity for written information.—Even a rough sketch may convey at a glance an idea of the form of a hill, the direction of a winding road or river, and the shape of an irregular wood better than elaborate writing can do. But it is not possible to convey all needful information by means of conventional signs, which, if unduly multiplied, would prove distracting. Hence it appears that in most cases information must be recorded partly by drawings and signs, and partly by *written matter*.

To do good work in a short time, it is important to distinguish between what is necessary to be drawn or noted for military purposes, and what is unnecessary. Minuteness of detail is not always required, though fair accuracy must be. If circumstances do not admit of fair accuracy, the fact should be stated.

Amount of 'details' depends upon circumstances.—As to the amount and nature of detail, much will depend upon the object of the reconnaissance.

For example : It might be all-important to show the exact shape of a hill when reconnoitring a position for defence, though the same hill need be merely indicated in reconnoitring for a route march. And, on the other hand, for a march it should be shown that a certain pond cannot be used for watering horses, because it lies in an old quarry with high perpendicular banks, and yet this same fact might be wholly immaterial in reconnoitring a position for defence.

Again, in a defile or very woody country, or in a long straggling village, it may be necessary to show the bends of a road with all correctness ; but in an open level country this would not be required, as the whole road is practically under view, or fire, even though it may bend a little.

These examples will serve to show that circumstances must decide as to minuteness of detail.

Division of labour.—One and the same officer is seldom required to report upon all the roads, rivers, villages, woods, railways, &c. found in a large district. The work is usually

divided amongst several reconnoitrers on the principle briefly explained in page 104. But it is very useful for an officer to consider what observations he may with most advantage habituate himself to make, so that, under all conditions of ground, he may recognise the essential features.

Practice necessary.—He should *practise* his eye to judge distances, to appreciate slopes, to estimate quickly relative heights, and to take in all that comes within his range of vision. Soon he will come to do this mechanically without much effort. A man who takes the pains to learn how to draw with his fingers what he sees with his eyes, will come to notice on the ground many more particulars—and these more accurately—than he who puts nothing down on paper.

The power of estimating distances by eye can be much improved by practice. With good eyesight, on an ordinarily clear day, it is generally admitted that the following objects should be distinguished on the skyline :

At a distance of	10 to 12 miles,	church spires and towers.
,,	5 ,, 7 ,,	windmills.
,,	2 ,, $2\frac{1}{2}$,,	chimneys of a light color.
,,	$1\frac{1}{4}$,,	trunks of large trees.
,,	$\frac{2}{3}$,,	single posts.
,,	600 yards	window panes.
,,	250 ,,	roof tiles.

(*See* page 264, 'The Duties of the General Staff,' Von Schellendorf, translated by Lieut. Hare, R.E.)

For practice, *the beginner should observe every detail and jot it all down on paper*, though at first he spends much time in doing so. When he becomes better acquainted with the subject, he will know what information to record, and what may be omitted. It takes a clever artist to hit off a likeness with a few strokes; and it is only the reconnoitrer who has accustomed himself to observe everything who can compile a pithy report, and dash off quickly an illustrative military sketch.*

* A remarkable and instructive example of rapid sketching is given in the *Aide Mémoire*, vol. i. p. 533, which describes how Lieut. Bain-

We would caution a beginner not to be disheartened because he must do many things at first which he need not do on service, for by the time he is employed in war he will no longer require these helps, needful though they be to the inexperienced.

Reconnoitring should be first practised on foot, afterwards on horseback (*see* Instructions for N.C.O.'s, page 108).

Reconnoitring on horseback.—To be an efficient reconnoitrer an officer should be at home in the saddle; able to ride across country and through difficult ground without having his attention distracted from his work. His eyesight should be good, observation quick, and his physique such as to enable him to ride far without flagging.

It should be remembered that the variation of the compass is different in different parts of the world. The amount should be ascertained beforehand—it is published by the Admiralty, periodically in a chart. In the late expedition to Ashantee the variation of the compass was mentioned in the Q.M.G.'s instructions.

The reconnoitrer should be provided with good field glasses, sketching case,* spare paper, prismatic (or common) compass, protractor (with scale), two lead pencils (HHH and F), red, blue, and green chalk pencils, penknife, india-

brigge, during the Peninsular War, accomplished a sketch of eight or ten square miles of most difficult country, near Salamanca, and partly under the enemy's fire, in less than three hours.

* Most sabretaches are inconvenient for use as sketching cases. The Staff College cases are too large and too heavy. The 'Woolwich pattern' sketching case is a serviceable article—to be procured from Messrs. Wickwar, 6 Poland Street, Oxford Street, London, price 11*s.* The metal rim should not be of iron, which affects the compass if laid upon it—copper or brass would be better, though heavier and more expensive. A piece of strong millboard, or the back of an old book, with two common india-rubber bands to fix the paper, answers the purpose very well, especially if a waterproof cover is also provided. The sketching case should be capable of being slung over the neck to free the hands, and to prevent the chance of its being dropped when reconnoitring on horseback.

rubber, and note book.* A piece of stout string about ten yards long, with knots at every yard, is useful for sounding, measuring bridges, &c.

The reconnoitrer should clearly understand what he has to do, before starting, and, when practicable, he should take a map of the country with him. Lastly, he should know his horse's paces at a trot and a walk (*see* page 112, note *).

SECTION II.

RECONNAISSANCE OF A ROAD.

Colonel Hamley in 'Staff College Exercises' says:—'The actual sketching of roads is a valuable exercise, as a preparation for the contingency of operations in a country of which no maps exist, and important service of this kind was rendered by trained officers in the late operations on the Gold Coast.'

A road reconnaissance is the best to begin upon. It is the most illustrative of the subject, the easiest to carry out by rule, the most commonly required, and the most generally useful in reconnoitring a district.

When no map is available the road must be 'traversed' (*see* page 21, Part I.)

Scale.—The best scale, for practice, is 4″ to 1 mile; for service, 2″ to 1 mile,† or 1″ for long rapid reconnaissances.

Details.—Mathematical accuracy is not required. Fences between fields seldom need be accurately drawn—it is enough to indicate that fences exist.

* A useful memo. book for field service, which may be also used for sketching, may be bought at Messrs. Newman's, 24 Soho Square. Certain headings are printed on each page to facilitate the despatch of orders in the field. Paper, best bank post, ruled into squares, representing 100 yards each on the 4″ scale. This tough thin paper admits of a very good copy of the original drawing or writing being traced through by means of black lead paper.

† Very expert and neat-handed draftsmen can show almost all that is necessary on the 1 inch scale, but for ordinary persons this is too small for a field sketch.

Small detached houses, single trees, peculiar rocks, &c., insignificant in themselves, may serve as useful guides for the march of troops—they should be put in, and if important, a rough free-hand sketch of them added.

Public-houses and inns which bear a name, whose whereabouts is known throughout a district, should be shown as P.H., with name noted. Frequently these names will prove more useful when inquiring one's way, than the names of hills and hamlets as given in old maps—especially in England.

Ground adjoining.—An ordinary road sketch should indicate the ground on either side for about $\frac{1}{4}$ mile on a large scale, and $\frac{3}{4}$ mile or more on a small scale, and this can in most cases be done without quitting the road. Occasionally notable points, much farther distant, must be put in, by taking cross bearings upon them—for example: a conspicuous church, a village, railway station, bridge, or a remarkable hill.*

Woods.—When a road runs through a great wood, if the outer boundary of the wood is not examined, it should be so stated, lest a wrong idea may be conveyed as to its extent.

Gradients.—In every road sketch, the positions of steep inclines, up or down, must be indicated. A very few lines properly drawn will show these slopes, as explained in Part I. (Also *see* Instructions for N.C.O.'s, page 108.)

It is found useful to draw a bold line right across the road at the end of every mile, on the 2 inch scale, and proportionately for other scales.

The above remarks apply to reconnoitring on service; but for practice, and whenever great accuracy is essential, the instructions contained in Part I. must be carefully carried out.

* The reader will probably remember how the two lone trees guided the march of an army corps before the battle of Königgrätz. And a church spire did like service at Bautzen.

SECTION III.

THE REPORT.

By 'The Report' we mean all the information that is conveyed in *writing*. This may appear either (1) wholly on the face of the sketch, or (2) on a separate paper, or (3) part on the sketch and part on separate paper.

In favour of (1), only one paper is required, and ready reference can be made from sketch to report, and *vice versâ*. But it is sometimes difficult to avoid confusion if much has to be written, unless it is to be interpreted by the reconnoitrer himself, same as shorthand writing.

In favour of (2) a fixed form of report may be settled, suitable for all conditions of ground. But there is the disadvantage of two separate papers being always required, which it is difficult to manipulate, especially on horseback in windy weather. Besides, it will often happen that all the information may be jotted down on the face of the sketch without confusion.

The best rule seems to be, to put on the sketch all that is practicable, and to use separate paper only when absolutely necessary.

In 1876 the Director-General of Military Education issued the following

Instructions for all Reconnaissance Sketches accompanied by written Reports:*

'The Sketch to contain all necessary information which can be put in without confusion.

'The written Report to be supplementary to, and explanatory of, the Sketch, to be framed strictly in accordance with the Instructions for Arrangement' (*see* page 77), 'and to convey necessary information with the utmost conciseness.

'To be written on foolscap, half margin, on the outer half

* These are drawn up for officers 'under instruction,' to teach them to systematise their Reports.

only, in paragraphs according to Instructions for Arrangement; the whole of the inner margin to be left blank.

'Necessary references connecting parts of the Report with parts of the Sketch in capital letters, A,B,C, &c.

'The Sketch to be attached to left hand of inner margin of Report at top and bottom, loosely with tape; the bottom of Sketch level with foot of Report.

'The Report to be headed by a title, and signed with the officer's name, and dated.

'The title and signature to be clearly written on the back of the Sketch.

'The Instructions for the work to be appended to the last sheet of the Report.'

In addition to the foregoing Instructions the following may be added:

Names should be correctly spelt: local names as known in the neighbourhood should be given, and sometimes it is useful to add their phonetic spelling. A very experienced staff officer strongly recommends that names of persons or places should always be written in Roman characters. Writing to be legible. Reference to be made to 'North,' 'South,' &c. rather than 'right' or 'left,' except in the case of river banks. Assertions that a river is impassable, a country inaccessible, a position impregnable, or roads impassable, should only be offered on most accurate information, and, if not from personal inspection, the authority must be given. Bear in mind that such expressions as 'wild,' 'flat,' 'hill,' 'mountain,' &c., are relative terms, and do not always convey their meaning, as a 'mountain' in one country might be described as a 'hill' in another.

Instructions * *for the Arrangement of Road Reports.*—'1. The Roadway—general directions, as N., N.E., &c.; nature hilly or otherwise—state the average gradient and the greatest gradient, with extent and locality. Construction—metalled or not, present condition, and material for repair

* These have been issued by the Director-General of Military Education for officers 'under instruction.'

obtainable. Width, in feet, of carriage way. Bridges and fords (fully) *seriatim*. Hollow ways, defiles, &c. Streets—in villages and towns on the road.

'2. Country—General nature of the country in which the road lies, whether in a valley, hilly ground, cultivated land, &c. Nature of contiguous fences; facilities for moving on particular fronts of formation. Woods, especially such as are near the road.

'3. Halting places—including facilities for watering—and shunting places, where part of the column at need could pass by that part in front of it.

'4. Camping grounds, or suitable bivouacs, and for what force.

'5. Positions on, or adjacent to, the road, suitable for the advanced guard.

'6. Nature of the position, within range of the road which the enemy might occupy (these to be judged of as seen from the road).

'7. Lateral communications (if not reported on separately). The Report on these includes the points where all roads or tracks practicable for any arm join the roads traversed by the column; and information respecting them, as detailed above, for the roadway only.'

With reference to the numbered paragraphs in the foregoing Instructions, and a few other matters not directly mentioned therein, the following remarks are offered:

1. *Gradients* of 5° and upwards should be accurately given, with their position and extent. Slopes steeper than 8° are almost impassable for heavy baggage wagons without extra horses. Guns can ascend slopes of 16° or 17°.

Construction, whether macadamised (with stones broken into angular pieces), or gravelled, or paved—all coming under the term 'metalled.'

Condition, good, fair, or bad—the whole or in part. Whether heavy (as sandy soil would be in dry weather), or sticky (if the soil is clay and the weather wet). Whether drained on either side. Unfenced roads running along

steep hill sides are liable to wear away on the outer side. Mention whether bad parts may be avoided by following another route near by.

Materials for repair.—Loose stones from neighbouring quarries or from stone walls; wood fences, hurdles, brushwood, or small pine trees (as in the 'corduroy roads' in America), may be used to repair, and should be mentioned when likely to be required.

Width (in feet) ought to be 20 feet for the free and convenient passage of troops. Minimum limit is the breadth required for the passage of guns, singly in 'column of route,' which is about 9 feet and more at sharp bends. The axletrees of gun carriages are $6\frac{1}{4}$ feet long. Portions of road, differing very much in breadth from the average, should be noted. Sometimes the exact measurement should be given.

Bridges.—Their material, whether brick, wood, stone, or iron; breadth of roadway, length, number of spans, nature of piers; whether passable and safe for all arms. A bridge strong enough for infantry to pass four deep will bear cavalry in file, and guns singly. When a *low* bridge crosses *over* a road, its height should be given, lest it might unexpectedly obstruct the passage of wagons piled up with baggage (*see* page 87).

Fords (*see* page 87).

Hollow ways and defiles.—Long cuttings of 8 feet deep and upwards should be shown by the regular conventional sign and their peculiarities noted. At these points the roadway is usually narrower and the bottom bad from water lodging there. The break down of one baggage wagon in a long deep cutting might occasion great trouble and delay, and a column attacked in such a position would be placed at a serious disadvantage. If there is an easy way out of a deep cutting at one side, it should be noted.

In a *large defile*, describe the character of the ground in front and in rear, as well as the defile itself. Give its length and width, and the facilities for crossing it transversely. When the flanks are accessible but covered, describe the nature of the flanks, the communications which cross them,

and those which abut on the defile itself, with the view to taking up a defensive position if attacked.

Embankments should also be noted for reasons similar in principle to those mentioned above. Note their height and steepness, and liability to destruction by intention or accident, and whether they are made to avoid a deep descent (bridging over a gulley), or as a causeway through bad, marshy ground.

Streets.—Whether narrow, tortuous, or obstructed (*see* 'Villages,' page 95).

2. *Country.*—General nature, hilly or level, woody or bare. Soil, gravel, clay, sand, chalk, rock, &c. Pasture or arable, and nature of crops.

Fields.—Large or small.

Fences.—Those bounding the road or dividing fields, whether generally small or large; whether banks, ditches, walls, post-and-rails, &c.; whether presenting an obstacle to movement, or affording cover, or both. Unfenced roads running through a marsh or bog to be drawn as 'unfenced;' but the conventional sign for 'impassable for cavalry' (infantry, &c.) should be marked on adjoining ground according to circumstances, so that, when no such sign appears, the ground is to be considered passable for all arms.

Woods.—Nature of the trees, and whether passable for all arms (*see* page 90).

3. *Halting places.*—Best where there is dry grass or heather, trees or other shade in hot weather, road unfenced, water at hand, not in a village, space for troops on one side, so that ordinary traffic may not be impeded. When the enemy is near, many other points must be considered.

Shunting places.—Best where road is unfenced or very broad, with good ground on one side (Plate. XI., *fig.* 1. B); or the troops may pass into an adjoining field through openings in a fence and out farther on, to avoid countermarching; or may make a short detour by a branch road.

4. *Camping grounds* (*see* page 97).

Bivouacs (*see* page 100).

5. The consideration of '*positions suitable for an advanced*

Guard' is best treated under the head of Tactics. The object is to note positions near the road to which an advanced guard might push forward, or upon which it might fall back if attacked by the enemy. Clearly it would be a great advantage for the commander of the advanced guard to know this beforehand; he would move with greater confidence, and would play his part with better effect.

6. This too ('position for the enemy') comes under the head of Tactics, and will not be entered upon in this manual.

7. *Lateral communications*, if connecting two routes, both of which are to be used, should be reported upon in sufficient detail to show how far they are available for the passage of troops from one to the other. If a cross road leads both to a village near and to a town far off, note the distance of each, which may be ascertained from sign-posts, mile-stones, inhabitants, &c.

8. *Water* (*see* pages 83–90 and 98). When water is scarce, note in detail that which is available for the use of men, horses, and cattle on the march. Whether the banks are too high, or too marshy, or the bottom too deep in mud; or, if artificially made, whether too fragile to allow horses to get to the water to drink. Level of water should never be more than 3 or 4 inches below the horses' feet if standing on the bank. Deep pools with high perpendicular banks may be used for watering when there are portable pumps and buckets with the troops; but this is a slow process. Troughs are very useful: they may be made rudely of planks, taken from the wooden flooring of houses near by. A small and shallow stream, if dammed, may afford a good watering place. State the number of horses that can be watered at one time, allowing a front of one yard for each along the space available.

Rivers and water considered as an *obstacle* may be noted as explained in pages 84, 88–9.

Marshes.—Whether wholly impassable, or, if not, describe where they may be crossed, to be learnt from inhabitants and personal inspection. Quantities of rushes or rank grass

in a dry place near water are indications of marshy ground in wet weather. Frequently marshes exist at high elevations.

9. *Railways and Telegraphs* (*see* pages 91–5).

10. *Miscellaneous.*—Note the position of forges, bakers' ovens, corn mills, and wheelwrights on or near the road; also large houses suitable for headquarters, staff, hospitals, or affording cover for perishable goods.

Notes on the points above mentioned may be readily made on the ground. From these short notes a full report may be drawn up on returning to camp or quarters.

Written notes on face of sketch.—A beginner should next take his original sketch (not the fair copy), and write upon it in pencil (for practice) as much of the information contained in his notes as may conveniently appear without confusion, and without writing in too small characters, but making free use of abbreviations. Each particular should be written, as nearly as practicable, opposite to the corresponding point on the sketch; and when this cannot be done conveniently, a fine line should connect the note with the corresponding point on the sketch (*see* Plate XII.). All *general* information, which applies to the whole sketch, should be collected together and placed, if possible, at the top of the sketch.

When the learner has been taught what to note down, a new example should be executed on fresh ground, when information is to be noted on the sketch itself at once, and a fair copy of the whole afterwards made indoors, on the same or a smaller scale (*see* Plate XIII.)

The reconnoitrer must use his judgment how far to enter into the details already explained. The orders he receives will usually decide his course.

Scarcely any allusion has been made to 'the enemy' in the foregoing remarks, as this phase of the subject is best treated under the head of Tactics.

A road sketch may be required for a simple route march,

when the enemy is far off and need not be considered. In this case many of the points before mentioned need not be alluded to.

A reconnoitrer will show his intelligence and knowledge of the subject by giving just that information which is needed, and no more.

Practice in drawing hills as seen from the road, without leaving it, is most useful, and this may be accomplished with less difficulty than at first sight would appear.

SECTION IV.

RECONNAISSANCE OF A RIVER.

When an original sketch of a river must be made, there frequently arises the practical difficulty of walking or riding along its banks. Walls, tributary streams, private grounds, &c. obstruct the observer's movements, though on service some of these difficulties would disappear.

When the bank cannot be traversed as a road, the bends of the river may be put in by cross bearings, or by taking offsets.

On still water the river may be sketched from a boat—the average length of each stroke being known. But the most accurate method is for one observer to go by land, the other by boat, noting the particulars by the way, the two approaching one another now and then.

The general direction of a river may be traced for long distances by the eye, even though the water itself be not visible, by observing the rows of willows or reeds lining the banks, or by noting the position of the bridges.

The principal objects of reconnoitring rivers may be classed under two heads: First, when the course of the river is in the direction of the 'line of operation'—the object of the reconnaissance being then to show how connection may be maintained on the march, or for action, by a force moving on both sides.

Second, when the river is to be used as a defensive obstacle.

Under the first head the following points should be reported on :

1. General nature of the valley in which the river lies.
2. Nature of the stream itself.
3. Tributaries.
4. Bridges, fords, and their approaches.
5. Other points at which passages of the stream may be made practicable.
6. Boats.

Under the second head in addition to the above :

7. Nature of approaches, and how they may be barred.
8. Hills on either side.
9. Inundations.
10. Points on either bank suitable for covering or barring the passage of troops.

The foregoing headings will now be explained in detail.

1. Valleys usually widen towards their mouths. Valleys descending from the centre of a ridge of hills usually run at right angles thereto ; those descending from the extremity of a ridge radiate like a fan.

The bank which is on the right hand of an observer looking *down* the stream is called the 'right bank ;' the other the 'left bank.'

Roads running parallel to the river should be noted, as well as means of access from them to points on the river banks. These may be examined on the return journey after the river itself has been reconnoitred.

Report whether the valley generally is wide or narrow, swampy, rocky, wooded or open.

2. 'Nature of the stream' includes its average *breadth*—which may be estimated roughly by eye, or more accurately by taking cross bearings. Streams, with low banks running in wide valleys, vary in breadth in different seasons, from overflows—a liability to which may be inferred from the presence of rushes or marshy ground in the ground adjoining, and from stray bits of drift wood and weeds washed into the branches of river-side trees.

Note how far the river is *navigable*—between what points, at what season, and for what class of boats. Also what dangers may be encountered in the way of sandbanks, sunken rocks, eddies, &c. This information is particularly desirable when barges have to be towed from the bank.

Quality of water to be ascertained by personal investigation (*see* 'Camping Grounds,' page 96).

Note whether the river is liable to be *frozen*, and to what extent. Ice three inches thick bears infantry in small detachments ; four to seven inches bears cavalry and light guns.

Depth.—If fordable, details to be given (*see* 'Fords,' page 87); but if otherwise, note average depth, to be ascertained by inquiry on the spot, or by sounding with measured string from a boat or bridge (though the latter is rather deceptive) ; or a string with a stone tied to the end may be thrown into the river from the bank and allowance made for the slanting direction.

A stream being rapid—unless after a freshet—indicates little depth. If the river be liable to floods, give maximum depth ; if liable to become dry, give minimum depth. The former may be ascertained by inquiries and by observing marks left on bridge piers and posts.

If a stream bends suddenly it is deepest on the outside of the curve and shelving on the inner side.

Bottom, or *bed* (*see* 'Fords,' page 87).—If at a point suitable for a military bridge, state whether the bed is even or rough, hard or soft, shifting sand, firm and level rock, of equal or varying depth across ; and if any deep holes are discovered, state where they are. Torrentuous streams are likely to have rocks or boulders in their bed, whilst streams with clay banks have a soft, muddy bottom.

Banks are steepest in swift streams. State average height above level of water. Whether steep, shelving, slippery, sticky, marshy, or firm. If high, which bank commands the other, and to what extent. What points are hidden from view and likely to be used for bridges by the enemy. What facilities for cutting ramps to allow horses or carriages to enter the water. Whether the banks are lined with trees

interfering with towing. Whether regular towing path exists, and on which side.

Current.—Partly upon this depends (1) the rapidity of forming an inundation, or reservoirs for drinking purposes; (2) difficulty in forming bridges and fording.

The 'surface velocity' may be calculated by throwing a piece of heavy wood into the middle of the current (a light object would be affected by wind), and noting the time it takes to travel a known distance—say 100 or 200 yards.

If the current runs at the rate of

1 mile an hour, or 100 yards in 3′ 24″ .	the stream is termed		sluggish.
2 miles an hour, or 100 yards in 1′ 42″ .	,,	,,	swift.
3 miles an hour, or 100 yards in 1′ 8″ .	,,	,,	rapid.
4 miles an hour, or 100 yards in 51″ .	,,	,,	very rapid.
6 miles an hour, or 100 yards in 34″ .	,,	,,	a torrent.

When considering *floating* military bridges, the 'surface velocity' should be known. When considering the nature of the bed, the velocity at bottom should be known. When calculating the amount of discharge, the 'mean velocity' should be given, which is in ordinary cases $\frac{4}{5}$ of surface velocity.

Islands should be shown on sketch. Give their size and description; whether wooded, bare, or marshy. Whether the opposite bank can be seen over them.

Canals.—Whether for irrigation, navigation, or draining wet lands. Give width, depth, slopes of banks; tunnels, cuttings, and embankments. *Locks*, their length, width, drop of water, how destroyed and the probable effect. Time taken to fill and to empty the lock.

3. *Tributary streams* usually run into the main water-course obliquely. Note their width and how they may be crossed, and how far navigable.

4. *Bridges.*—Whether fit for all arms, and in what formation, as, 'infantry in fours,' 'cavalry in half-sections,' &c. Present condition, construction, material, length and breadth, number of spans, and thickness at crown of arch. Also nature of the piers, with a view to their hasty demolition or repair. If destroyed, the nearest other passage and how reached. Facilities for fording river near bridges, so as to

prevent a column, passing over on the line of march, being lengthened out by the narrowness of roadway at bridge. Under which arch it is best for boats to pass. If the arches are low (less than 9′) or narrow, give dimensions, in view of loaded boats passing through.

5. *Fords.*—Their exact position. Any peculiar marks on the banks by which they may be readily found. Their length, breadth, and nature of bottom—whether sand, clay, gravel, or rock, and whether there are any deep holes to be avoided. Fine sand becomes hollowed out by horses' feet passing, the loose stuff is carried away by the current, and the ford deepens. Whether quicksands form in ford, rendering it unsafe. Describe approaches to ford; nature of landing-places on either side; velocity of current; liability to deepen through rise of tide or floods or opening of sluice gates above. Show in sketch the configuration of the ground on both banks, and height above water. *Depth* at ford for cavalry not to be more than 4′ 4″; for infantry 3′ to 3′ 6″, according to strength of current; for guns and ammunition wagons 2′ 4″, or deeper if the ammunition be removed.

Fords may be expected at the mouth of widening portions of the river (*see* Plate XI., *fig.* 2), or from one sandbank to another between which the current is very strong, or obliquely across a winding stream between two inner curves B, B (as at Plate XI., *fig.* 2). Roads and cart or cattle tracks, leading into a stream on one side and out on the opposite bank, indicate fords. In hilly countries fords are frequently obstructed by large stones, inconvenient for horses and impracticable for carriages. In moor and heath countries the bed is often fine and shifting sand, dangerous and changeable—when fascines loaded with stones may be laid down to render them safe. The best bottom is coarse gravel.

'Always examine fords by crossing them yourself several times, backwards and forwards, and do not trust to reports of inhabitants regarding their non-existence.'

In seeking for a ford, if there are no indications as before mentioned, the best plan is to ascend or descend the river in

a small boat, provided with a short lead line and sounding pole.

It may be useful to remember that a ford in a deep and rapid river may be crossed if a heavy stone or other weight be carried, which would be dangerous without.

A ford at best is an inconvenient and often an uncertain means of crossing a river. When neither fords nor permanent bridges exist, temporary bridges must be constructed. The reconnoitrer should report upon the positions most suitable for these.

Positions for Military Bridges.—A bridge is most easily defended when it is (1) out of view of the enemy; (2) in a re-entering bend of the river; (3) where the defenders' side commands the other; and (4) when there is an open space on the enemy's side, so that he may be exposed to fire.

In all cases, at the points selected the banks should be firm, the approaches sound, not cramped, and not liable to be flooded, the river narrow (if not too deep), and the current slow. It is a convenience if the banks are level with the roadway of the bridge when constructed, but ramps may be cut if required.

Islands should be used as stepping-stones across.

Always give an accurate drawing on a large scale of the section of the river where it is proposed to construct a bridge (showing banks, bed, and level of water, with probable rise or fall).

If the river be broad and deep, a floating bridge of some kind will probably be best. Note character of anchorage up-stream, and down-stream also if in a tidal river. A tributary stream near by may be used to float the piers, &c., from the place where they are constructed safe from the enemy down to the point of passage. The river should not be too shallow near the banks, as it would be inconvenient if the pontoons, boats, casks, &c., were grounded.

If broad and shallow, the supports or piers would rest on the bottom. Select a spot where the bed is sound and even.

If narrow and deep, and such as might be spanned from one side to the other by some kind of spar bridge, select a

place where the face of the banks is sound but not rocky, affording a good bed for the butts of the standards to rest on. The height of the banks does not signify, as a truss bridge might be used for low banks, and a lock bridge (double or single) for high.

Ferries.—Position of, size, number, and nature of boats, and how propelled across stream—by steam, ropes, or oars. Whether horses and carriages can be loaded from the banks.

6. *Boats.*—Average size, nature (whether flat-bottomed), strength, and condition, and number procurable. Even small boats, if strong and not too slight in the gunwale, may be used for bridging. Whether any river steamers (for towing) and large barges are available. What materials at hand for rafts : such as trees, wood from timber yards, house rafters or beams, casks, &c., and their exact whereabouts.

7. In reporting upon the nature of *approaches* and how they may be *temporarily barred*, bear in mind that narrow deep lanes are easiest to obstruct, by cutting down trees and laying them across ; also by cutting deep holes and trenches across and letting in the water from the river.

8. *Command*, and distances, from stream, of *heights* on either bank to be given carefully at points within firing range of passages across the river—at other points the information is required in general terms only.

9. When noting places suitable for *inundations*, remember that inundations are usually wide, but shallow, on broad level ground, and limited in extent, but deep in a narrow valley. A railway embankment across a valley will form a dam if the bridge be blocked with stones, weighted faggots, trees, and clay.

Sometimes the river level is above the level of the country, the water enclosed between artificial banks—in such cases an inundation is easily effected by cutting through the bank.

On ground liable to a natural inundation, note all raised causeways, and the safest route to follow (by known landmarks) when there is no dry land.

Note position of sluices and weirs.

On level ground an extensive inundation, 2 feet deep, presents a serious obstacle, unless the roads are very sound and their directions marked by trees, posts, &c. Lines of telegraph posts frequently indicate direction of main roads, but a slight dip of 3 or 4 feet might render these roads impassable. A railway inundated soon becomes dangerous, the water undermining the rails by washing away the ballast from under the sleepers.

When a large level district is covered with water, the direction of streams running across should be known—this may be inferred from the position of bridges, which may be seen from a distance, or by noting where there is a greater rush of water.

SECTION V.

RECONNAISSANCE OF A WOOD.

First follow the principal roads through the wood; then skirt round the edge, and follow along ravines and streams leading into it, and observe all that can be seen from the highest ground within the wood and outside. Carefully note character of country at the entry and exit of roads.

Examine nature of trees; whether all arms can march through the wood itself, or only along the roads—and, if the latter, state the reason, whether because of underwood, or marshes, or the trees being too closely planted or their branches too low.

Note all large open spaces, and show them on sketch. Also whether practicable to open up new routes by cutting through narrow patches of wood. Whether roads easily blocked by felling trees.

Note whether edge of wood is clearly defined or otherwise.

Where there are no roads, note the remarkable trees,

rocks, towers, &c., which might serve as landmarks for troops on the march, giving compass bearings from these on known points. When the tracks are badly marked at cross roads, give compass bearing of route to be followed—the trees may be marked by chopping off slices from the bark to indicate the route.

All villages and water inside the wood must be reported on. Also points from which a good view may be had of surrounding country. Carefully note where every road leads to, and its distance (*see* Plate XIV.).

SECTION VI.

RECONNAISSANCE OF A RAILWAY.

1. Report upon capabilities for conveyance generally—the rolling stock, engines, passenger carriages, goods, and cattle trucks—their dimensions (including height of covered wagons), condition and numbers.

In England 1st class carriages, with 3 or 4 compartments, hold 18 to 24 men; 2nd and 3rd class, with 4 or 5 compartments, hold 32 to 40 men with their arms. Average length 20 feet.

For English traffic all arrangements are made for smaller trains and higher speed than for Continental.

Calculation for conveyance of troops by rail in England, on war strength:

A Battalion of *Infantry* requires 2 trains of about 23 vehicles each, including horse boxes and break vans. If regimental baggage wagons and draft horses are included, add 10 to 12 trucks per train to above estimate.

A Regiment of *Cavalry*, with its wagons, requires 4 trains of 34 carriages each.

A Battery of *Artillery*, complete, requires 2 trains of 32 carriages each.

Carriage of supplies.—A goods truck carries 1 ton straw,

or $1\frac{1}{2}$ ton hay, or 5 to 7 tons coals, or 6 to 9 head of cattle, or 30 to 40 sheep, or 2,000 rations bread, or 7,000 rations flour.

An *engine* drawing a heavy load consumes 100 cubic feet, or 660 gallons water, and 8 cwt. pit coal per hour. From these data may be calculated requirements of coal and water at a station.

2. *Stations* (*see* example, p. 93).—Mention its name. A great object to be obtained in the movement of large forces by rail must be to increase the facilities of embarking and disembarking* to the utmost; and these mainly depend upon the arrangements of the stations, and the size and nature of the platforms.

Platforms.—There should be ramps at the ends, with easy access thereto for horses; and baggage wagons should be able to be entrained on the trucks without unloading. Remember that horses require platforms, permanent or temporary—men do not.

Platforms should be 20 feet wide, and long enough to take in the whole train. Note the length, breadth, height, and material of platform.

Platforms are most useful when troops may be entrained, &c., without interfering with the 'through traffic,' so that the main line may be kept open for other trains to run through.

Note also length available for entraining guns and wagons at other places—and facilities for erecting temporary platforms, in continuation of existing ones, or at new places; this is easy if the station is on the level, and the ground not swampy.

Report length and number of sidings, switches, turntables, 'crossovers' (by which men may cross while trains are running), cranes, water and coal supply.

Also whether any large storehouses or sheds are near, to

* The terms 'entrain' and 'detrain' may conveniently be substituted for 'embark' and 'disembark,' as suggested by General Hamley in 'Staff College Exercises.'

be used as depôts or as hospitals for men who cannot continue their journey.

Whether facilities for supplies of hot water * for coffee, &c., during temporary halts, and water and buckets for horses.

The following report on Staines Railway Station (see Plate XV.), London and South Western Railway, is given as an example † :

Platform.—'Down' 160 yards long by 3 to 4 broad. Earthen, gravelled, faced with brick, $1\frac{1}{2}'$ above rails, $2\frac{1}{2}'$ above road—difficult to widen, impossible to lengthen.

Entrances—at A (10′ gate), with ramp—at B (4′ gate). Both could be widened and ramps made. Roof over platform supported by pillars.

If paling removed, wagons could be conveniently unloaded from the road on to platform.

'Up' 110 yards long by 4 to 5 broad—earthen, gravelled, 2′ above rails—might be lengthened westward.

Entrances F, F (4′ gates), both might be widened. Slight ramp west end, but very narrow at M. Pillars on platform supporting roof.

Sidings (clear of the points).—250 yards along Reading line; 200 along Windsor. Both suitable for entrainment of infantry only.

Switches as shown.

Turntables, two T, T, for trucks only, not for engines.

Crossovers, none—but bridge 400 yards eastward carries main road across railway.

Cranes, two, north side.

Horses could be loaded at K (one truck), which could be lengthened—also at D (3 boxes) capable of being lengthened towards the siding, and temporary platform made.

Guns and wagons loaded at H and C, end on—but heavy

* The Germans used hot jets of steam injected from the engines into cans for heating water for coffee, &c.

† The particulars given in this example do not profess to be strictly accurate; they were collected and the drawing made in about an hour, under very disadvantageous circumstances.

pull up ramp. Trucks when loaded could be run on to sidings east and west out of the way.

Water—two columns (E, M) for engine supply, connected by pipes with tank L.

Coal—average supply about 50 tons.

Goods shed G, 70′ × 35′, brick, and shed at P available for temporary shelter. Also many buildings in village of Staines suitable for stores, hospitals, &c. Fire buckets useful for watering horses.

Outside.—On south side a good road 20′ wide leads to bridge—with space at Q, 250 yards × 35, useful as a rendezvous for troops or for parking wagons before entraining. On north side there is ample space in large fields ¼ mile from station.

H. G. M.

Capt.——Reg.

Dated

• *Outside the station*, report upon the number and size of entrances, whether approached by steps. If approach to platform not available for horses or carriages, and if the station is in a cutting or embankment, it is only good for entraining infantry. Note what space outside for forming up troops or parking wagons before entraining. Whether station is in an embankment, cutting, or on level.

3. *The Line.*—Give the name of railway (as 'Great Western,' &c.). Whether double or single; gauge * accurately in feet and inches, inside measurement; description of rails and how laid on sleepers, whether longitudinal or transverse.

Bridges, cuttings, embankments, and level crossings. Tunnels, length, how revetted, soil.

Note points on the line where troops can be quickly got out, or stations extemporised—that is where the line is on

* The gauge of railway from Russian frontier as far as Jassy (north of Roumania) is that of Russian Railways, 5 feet. The Roumanian, Turkish, and Austrian railways have gauge of 4′ 8½″. The difference being arranged for strategical purposes. But the Russians have arranged their carriages so as to shift wheels to fit new gauge.

the level, where rails to form sidings can be laid in, and which are close to a main road.

Telegraph—number of wires, and where connected with.

Distance between stations—Heights commanding the line. Defensive capabilities of stations. Supplies of rails, sleepers, &c., should be noted.

Junctions.—Whether line to required destination goes straight forward, or whether necessary to shunt and go back.

When two lines cross, state whether a train can be shunted from one line to another. If it cannot, whether facilities exist for making a short junction between them. This may be when one line is on the level and the other on an embankment, merely high enough to pass the engine below the other. Otherwise making a junction rapidly may be considered difficult.

SECTION VII.

RECONNAISSANCE OF VILLAGES.

Some idea of a village may be obtained without going inside. Villages built on hilly, rocky, or marshy ground are usually irregular—the houses are scattered. If there is a stream, the houses usually line it on either side. On even ground the number of main streets and their general direction may be inferred from the roads running into the village.

An open space may be expected near a church or large public building.

Note character of ground all round, especially that bordering roads on outskirts of village. Can the village be commanded by Artillery and whence, and does the ground afford cover?

When time and opportunity permit, examine carefully open spaces inside, nature of enclosures round the houses (whether hedges or walls, high or low). What houses available for depôts, hospitals, or barracks. The *houses*—material, size, whether thatched, tiled or slate or wooden roofs: whether detached or touching. Position and size of church and church-

yard. What good points from which to observe surrounding country. *Streets*—whether narrow or tortuous, whether suitable for heavy traffic. Position of post office and telegraph.

Note whether an enemy could reconnoitre village from a distance.

Water—its quality, quantity, and how reached, and whether it could be cut off by an enemy.

Whether village may be passed, by leaving main road and making a detour.

Give the names and addresses of persons who could afford information.

For 'supplies' and 'accommodation' see pages 106, 107.

The capabilities of the village for defence would probably be noted in a separate report.

SECTION VIII.

RECONNAISSANCE OF A CAMPING GROUND.

The best site for an encampment or bivouac, when troops are liable to be attacked, is under cover of the position they would occupy for defence and not actually upon it, but near enough for all requirements of speedy occupation.

It is a great advantage to be independent of tents because of the transport they require. If close to the enemy the troops may bivouac, and if distant they may be in cantonments.

But tents may be required in sparsely populated countries; and, as the sanitary principles which apply to camps hold good for bivouacs, *the selection of camping grounds* will now be considered.

For convenience of arrangement, the Report may be divided as follows:

1. *Site*—including (*a*) its sanitary aspect; (*b*) general convenience; (*c*) communications.
2. *Extent* and *Shape*.
3. *Water*, *food*, and *fuel*.

4. Suitability for proper *distribution* of the various arms and the non-combatant departments.

1. *Site* to be healthy—drainage good from nature of soil or gentle slope. Sand, gravel, and chalk the driest. Clay, newly ploughed ground, the site of an old encampment, marshy land, and brushwood (unless on sand or gravel) are bad. In a forest even an open clearing is unhealthy because of decaying leaves.

General convenience.—Slopes not too steep, especially for cavalry. Hurdles, brushwood, branches of trees, heather or straw are useful for giving additional shelter and bedding (especially for bivouacs). Convenient to have a market town near.

Communications to and from camp, as well as those inside, to be sufficient in number and good. Site not to be obstructed by ravines, marshy, or bad ground—and if these exist, note best points of passage across.

2. *Extent* required depends upon the number and nature of the troops, and whether the camp is to be occupied for a long or a short time. As a rough guide calculate as follows for temporary camping grounds:

War strength.—For one battalion Infantry 130 yards square. For one regiment Cavalry 200 yards front, 150 depth. For one battery of Artillery 130 yards front, 100 depth.

When a brigade or division is to be encamped, calculate for each battalion, regiment, &c., on above data, and allow fully double that total space for the whole encampment, to give room for hospitals, head quarters, commissariat depôts, engineer and ammunition trains, police, &c., and for spaces between corps, and for ground unsuitable for occupation.

The *shape* should allow a convenient arrangement of all arms, as briefly explained below in paragraph 4.

3. *Water.*—Good and abundant—best from running streams fordable here and there with good gravel bottom.

Facilities for filling water carts (best to run them into water 2′ or 3′ deep), and for watering horses, either by walking them into water not less than 4″ or 5″ deep, or by constructing wooden troughs (easily made with planks from house floors) or trenches dug in the ground, filled by buckets or portable pumps, or the stream itself may be diverted into them.

A horse or bullock drinks about 1½ gallon at a time, in 3 minutes.

Drinking and cooking water for men should be taken *up stream*; next, water for horses and cattle; next, bathing place; and last, washing place, farthest down the stream.

If water be scarce, find best place for a dam, or where to sink barrels to collect a supply.

Seeking for water.—'Surface springs should be sought for in depressions below the general level, where the earth is moist, or where the grass is unusually green, where gnats hover in swarms, or where the mist rises thickest in the evenings.' Also seek under stones in dry watercourses, or where birds direct their night flights, or where the bushes grow in sandy soil, or, in wild countries, the points where paths of men or animals converge.

Testing water.—'Drinking water should be clear and free from colour, taste, smell, or deposit, on standing.' 'Water from small ponds or shallow wells should be avoided.'

If a stream have a muddy bottom, beware of stirring up the mud when dipping vessels into it.

Amount of water required.—Where water is abundant calculate as follows: Each man requires for drinking 3 to 4 pints a day. For drinking and cooking ¾ to 1 gallon. For drinking, cooking, washing, &c., at least 4 gallons. For hospital supply, at least 40 gallons. Each horse requires for drinking 6 to 9 gallons.

To calculate amount of water supplied by a running stream.—Multiply together average breadth, depth, and velocity in feet per minute, and multiply product by 900, which gives the number of men for whom there is water supply, approximately.

The sufficiency of supply from wells may be tested roughly thus: Measure depth of water in well; draw off rapidly a given number of gallons, and note the diminution in depth and time taken to recover original depth of water—then compare this time with amount originally drawn off.

For *Food* see page 106.

Fuel should be at hand. Trees (about 1 foot diameter) with brushwood to start the fires. Pine trees and other soft wood are bad, but ash, maple, beech, birch, and other hard woods are good for fires.

4. The practical value of a report upon a camping ground is at once increased if information be given as to most suitable sites for each arm and for the departmental branches. The following hints may be of use:

Horses should be watered three times a day, therefore they must not be too far from water, nor picketed in the middle of the camp. The ground should be firm and the slopes gentle.

No tents should be pitched in the bottom of a valley, as sudden heavy rains would flood them; nor upon too low ground, but above the influence of miasma and night mists from rivers and swamps.

When practicable, no ravine, stream, or other obstacle should run through the camp of a brigade, certainly not through that of a regiment.

Main communications—whether roads or bridges—should be kept clear of tents.

Hospitals to be located on the healthiest sites, not near cavalry lines; and, in large camps, in rear of all, and conveniently distributed. It is convenient to place them near roads, on the way to a railway station.

Note the nearest post office, telegraph office, railway station, and market town.

Commissariat Depôts should have roads or good sound ground leading to and from them, in good communication with the whole camp and conveniently posted.

Sites for Brigade and Division *Head Quarters* depend more upon the position of the troops than upon the personal comfort of the staff.

Engineer Park and *Ammunition Train* to be near main roads and towards the rear.

Before making a reconnaissance of a camping ground the following points should be known by the reconnoitrer: The direction of the march into and out of the ground, and the number of men and horses, and the nature of the arms for which the ground is to be selected. Also the direction of the enemy.

The sketch should be on the scale of 4″ to 1 mile.

SECTION IX.

RECONNAISSANCE OF BIVOUAC GROUND.

'* In selecting a site for a bivouac, wood and water are, as for camps, the great requisites; but a good supply of the former is more essential for the bivouac than for the camp, as it is robbed of half its enjoyment unless the men can have fine fires to sleep near. This is all the more essential if the nights are cold. In cold weather, woods are the warmest place for a bivouac. In tropical climates it is pleasanter at night to bivouac in the open. The sanitary principles that apply to the selection of camps hold good in choosing the site for a bivouac; dry and sheltered positions should be selected,' with straw, heather, or pine branches for bedding, to give the men the best chance of rest. Fires are most important in warm weather also, at night, if there is mist or dew in early morning.

SECTION X.

RECONNAISSANCE OF MOUNTAINS.

For military purposes a knowledge of the roads, passes, and tracks over the mountains is what is principally required.

* Wolseley's 'Soldier's Pocket Book.'

If the lines of 'water partings' (or 'watersheds') of chains and spurs, and the watercourses of valleys and ravines are shown on the sketch, a very fair general idea of the whole mountain range may be gathered.

The sketch should show the relative heights of the principal hills, and their communications and points of connection.

Usually *roads* follow the lines of valleys. If two valleys run nearly parallel, a passable track may be found along the water parting of the hill between them.

Note particularly the worst and steepest points of the roads, and the parts most liable to be flooded by mountain torrents—and whether practicable for carriages, beasts of burden, or infantry only. Whether bad parts may be repaired, or altogether new routes followed to avoid steep inclines (up or down) or dangerous defiles.

Mountain *streams* are liable to sudden floodings—indicated by large round boulders lying in their bed. Ascertain from inhabitants to what extent these floods rise. The steeper the mountain slopes, the quicker the streams will rise. Fords across these streams are seldom good for horses.

Ravines may be dry one day and overflowed by a torrent the next; but when dry they may serve as roads, therefore ascertain where they lead to and where they join the main track.

Passes to be carefully reported on, especially if no other good road exists. The best pass is not always the least elevated; the latter are frequently marshy.

Remember that often it is easier to go round a hill, following a contour, as it were, than to go straight over it.

On very high mountains many passes are impracticable for months together, from snow-drifts. Ascertain particulars about this.

It is useful to note what points give the best views of surrounding country.

SECTION XI.

RECONNAISSANCE OF A SMALL POST.

An officer charged with the defence of a small post, or with the selection of one, is required to send in a report and sketch explaining all that should be told.

The sketch should be on a scale of 4″ or 6″ to a mile. It should show the *direction* of the enemy, and the positions of the picquets on either flank, and of the support; also *direction* of remarkable objects in front (as a church, village, hill top, &c.) as useful guides hereafter.

Usually a report separate from sketch must be rendered, not only describing the positions of sentries, detached parties, routes of patrols, &c., which may be shown on the face of sketch, but giving reasons briefly for all that has been done, and which would not at first be apparent to any one unacquainted with the ground. There should also be a general explanatory description of the whole ground.

This report to be written on half margin foolscap (when practicable) in the form of a memorandum, with names, rank, and regiment of writer and person to whom addressed; date, hour, and place from whence despatched, written at the top.

The report may be divided somewhat as follows, modified according to circumstances:

1. *General description* of ground—level, hilly, or undulating. The ravines, valleys, and hollows; the hills, spurs, underfeatures, and cliffs.

2. Facilities for *cover*. Woods, fences, walls, embankments, and natural dips.

3. *Water*—as an obstacle. Rivers, streams, large ponds, marshes, and how they may be crossed by defenders or assailants.

4. *Roads*, and all means of communication—even small paths and tracks leading to the front, rear, and laterally—those leading from the front through woods and hidden ground to be most carefully noted.

5. *Buildings* to be described in detail if intended to be rendered defensible and held.

6. *Commanding ground*, in front, rear, and flank.

7. *Disposition of sentries*, detached and examining parties, and routes of patrols, with reasons tersely given. Also how connection with other picquets and support is maintained, and how the main body of your own picquet is posted.

8. *Weak points*, which require careful watching, such as a wood or hollow in front, or a deep winding valley.

9. *Line of retreat*, if forced back in one direction or another, and how the retreat would be conducted.

10. *Second position* to which the picquet would fall back if necessary, and make another stand.

11. *Final retreat* upon the support.

By giving these particulars the relieving officer will know much that is useful even before he reaches the ground.

SECTION XII.

RECONNAISSANCE OF A POSITION.

Properly to reconnoitre a great 'Position' with a view to *selecting* it for defence, requires a wide knowledge of tactics, and the duty would probably devolve upon officers of superior rank.

But a commander may have selected a locality generally as likely to afford a good defensive position ; his knowledge from maps may enable him to do this without having examined the ground personally. Details, however, may be required which his maps do not show, in which case reconnoitrers would be sent forward to gain this information. They would make a detailed sketch of the whole ground (scale 2″ or 4″ to 1 mile), or a trace or enlarged copy taken from some existing map would give general features, afterwards to be filled in, and a report sent in explaining all matters of tactical importance. This, however, is a subject which goes beyond the limits of this manual.

The possibility of many tactical formations depends much upon the slopes of the ground. A slope of 10° has a considerable effect on the movements of infantry in close formation. On a slope of 20° the movements of cavalry and artillery cannot be carried out in an orderly manner, except as single horsemen. A slope of 30° may be considered as impassable for infantry in close formation.

SECTION XIII.

ARRANGEMENTS FOR A CONCERTED RECONNAISSANCE OF A DISTRICT.

It may be necessary on service to have a tract of country —say 10 to 12 square miles—quickly reconnoitred.

The number and skill of the reconnoitrers requisite will depend mainly upon the nature of the country, the *amount* of details needed, the time allowed, and the nature of the maps available.

Before starting, all available maps should be carefully studied—it will save time in the long run to do so—and each officer should have some specific work allotted to him.

The following example may serve as a general guide how to set about such a task, without going into details which do not come within the scope of this treatise.

See Plate XVI.

Example.—A rapid reconnaissance is to be made of the country between Croydon, Sutton, Banstead, and eastward to Red Lion (London and Brighton Railway), with a view to reporting the facilities afforded for moving troops over all parts of this district, and bivouacking them thereon. The enemy is towards the north; line of retreat southward. Reconnoitrers to start from Banstead.

Three reconnoitrers might examine this ground by following the routes as below.

[The dotted lines, lettered, indicate the several routes, with arrow heads to show the direction to and fro.]

1. Route A, A, going out by high ground, in order to

have a better view of the whole country, and returning by the railway and valley.

2. Route B, B, examining cross roads to south on the way out, and those to the north on return journey. A shorter distance than A, A, because ground more cramped.

3. Route C, C, examining railway, means of crossing it, stations, &c.

SECTION XIV.

COAST RECONNAISSANCE.

A coast line may have to be reconnoitred with one of two objects, (*a*) with a view to defending it against a hostile landing; (*b*) with a view to effecting a landing. In both cases pretty much the same sort of work will have to be done, as the pros and cons must be ascertained on both sides.

The report may be arranged somewhat as follows:

1. *The offing.*
2. *Topographical description* of beach and foreshore.
3. *Country* inland within cannon shot.
4. *Communications.*

1. From charts, 'Sailing Directions,'* or local pilots or experienced fishermen, ascertain depth of water, to show whether large ships may approach the shore, to cover a debarkation with their fire. Describe position of sandbanks and dangerous rocks. State rise of tide; prevailing winds; anchorages; whether the bottom is 'foul' with rocks, or of sound good holding clay.

2. Width of beach at high and low water; whether sand (hard or soft), shingle, mud, or rock; whether bordered by cliffs, sandhills, &c., and points affording passage from beach inland. Liability to heavy surf, and how far depending upon direction of wind. Whether beach, and country imme-

* Books are published by the Admiralty giving minute information on all these matters, and may be purchased by any person.

diately behind, is under fire from the ships. Whether hills or headlands afford suitable positions for the defenders.

3. Nature of country inland; whether level, hilly, open, woody, &c. Whether liable to artificial or natural inundations. Nature of soil. Whether intersected by hedges, deep drains, swamps, &c. What position is favourable for defence against the invader, and what points the enemy might occupy with a small force,* to cover and hold the landing place during the operation of disembarking his troops.

4. Note carefully how men, horses, and carriages can be brought from beach inland, marking the best routes or tracks leading to main roads, describing their suitability for heavy traffic.

Even small harbours may prove invaluable for landing heavy guns and stores. Describe in detail size and depth; also length and height of wharves, jetties, &c.

SECTION XV.

NOTES ON ESTIMATION OF SUPPLIES.

To find the number of tons in a stack, multiply together the height, breadth, and length in yards, and divide by 12 (for hay), by 17 (for straw).

'Height' is distance from ground to eaves + $\frac{1}{3}$ distance from eaves to apex (*see* Plate XI., *fig.* 3).

i.e. $$\frac{(A\,C + \frac{1}{3}D\,E) \times A\,F \times A\,B}{12} = \text{No. tons hay.}$$

A cubic yard of hay weighs 200 lbs. nearly.
" " straw " 140 " "
" " grain equal 20 bushels.

An acre of grass will yield from 1 to 3 tons of hay.
" " oats " " 50 to 60 bushels.
" " wheat " " 30 to 40 "
" " barley " " 40 to 50 "

* These detachments would probably be landed somewhere near, and would then push quickly forward to seize a favourable covering position.

20 lbs. of unthreshed corn form a ration.
28 lbs. green forage = 10 lbs. hay.
1 load of hay = 36 trusses, of 56 lbs. each.
1 truss of straw weighs 36 lbs.
1 bushel of oats weighs from 36 to 41 lbs.
14 lbs. of bran = 9 lbs. oats.

An averaged-sized	ox	supplies	300	rations.
,, ,,	sheep	,,	45	,,
,, ,,	pig	,,	110	,,

A load for a	horse or mule	may be estimated at	200 lbs.
,, ,,	2-horse wagon	,, ,,	800 ,,
,, ,,	4 ,, ,,	,, ,,	1,800 ,,

,, ,, 6 ,, ,, (general service new pattern) may be estimated at 3,300 lbs.

ACCOMMODATION.

An approximate calculation for temporary accommodation on the line of march may be made on one or other of the following data:

1. Allow 25 soldiers to each small house, or 100 to 200 to each large house.
2. For large buildings take $\frac{1}{4}$ number of square yards in the ground floor for number of men per story.
3. Multiply the number of flues by 6 for number of men.
4. In a room 15′ wide allow 1 man per yard of length. In a room 15′ to 20′ wide allow 2 men per yard of length. In a room more than 25′ wide allow 3 men per yard of length.

SHELTER FOR HORSES.

In outhouses, sheds, barns, &c., if 15′ wide, allow 1 horse to every two yards of length. If 24′ wide, allow 2 horses to every two yards of length.

SECTION XVI.

INSTRUCTIONS FOR COURSE OF FIELD SKETCHING AND RECONNAISSANCE OF GROUND FOR NON-COMMISSIONED OFFICERS OF INFANTRY, CAVALRY, AND ARTILLERY. ISSUED BY AUTHORITY.

The whole teaching must be based on the principle that the men are not to be trained as makers of maps, but as intelligent soldiers, who will be required, either to work alone, or to assist Officers in investigating as quickly as possible and reporting clearly the military capabilities of a piece of country, whether maps of it are already in existence or not.

The means used ought to be such as are likely to be available on a campaign; the Prismatic Compass, therefore, though a valuable instrument, the use of which should be known, must be considered as generally beyond the reach of the Non-commissioned Officers.

On the other hand, a Pocket Compass appears almost necessary for all Cavalry Officers and Non-commissioned Officers, as they may often have to ride by it; and it will be found quite sufficient for ordinary purposes of sketching roads or features of ground.

No class should consist of more than eight men, or ten at the very outside, and not more than four should be taken from each regiment, when the course is not carried out regimentally.

The materials required will be:

Some sheets of Drawing Paper (Whatman's pressed is the best, but white cartridge paper will do) cut into pieces of half foolscap size. Colours: Burnt Sienna, Crimson Lake, Prussian Blue, and Gamboge. Steel Pens (not etching pens, they are too fine). A few sheets of Bristol Board, or Card Board, cut into narrow slips, for scales and rulers. Camels' hair brushes with fine points (one for every two men will suffice).

For each man:

A common Magnetic Compass,* the needle of which can be clamped and unclamped at will.

A piece of stout Millboard, about 9 in. by 6 in. (the backs of old books would do), with two common india-rubber bands for each, and an extra band in the pocket lest one should break.

A good H Pencil and a small piece of india-rubber (not ink-eraser).

A red, a green, and a blue Pencil.

This is all that is absolutely necessary, but a Book for road traversing and a Boxwood Protractor should also be lent: so that the Non-commisioned Officers should learn the best way of traversing and plotting.†

The Instructor must have in his possession sufficient prismatic compasses to teach the use of them, as the work done by their means would perhaps be more accurate;‡ but the Non-commissioned Officers should be taught that they must on no account regard the prismatic compass as a *necessary* for field sketching. Much of the most useful work is performed in war without the use of any instrument.

The course will be four weeks of five working days each;—twenty days.

During the last week of the course there will be an examination conducted by the Instructor; who, from the results of it and his own knowledge, will divide the Non-commissioned Officers into two classes:

1st. Those who have shown such ability in field sketching, as well as in reconnaissance, that they might usefully be given further instruction, and become, in their turn, able to instruct.

2nd. Those who are capable reconnoitrers, but can only be rough draftsmen.§

* It should have a cover to preserve the glass, and a ring attached.

† *See* page 21.

‡ The men should compare a sketch done by means of a prismatic compass with one done by ordinary compass, to show them how correctly the latter may be drawn.

§ This class of men may, to a certain extent, make up for their short-

During the course, the Non-commissioned Officers should be taken off all stable duties except evening stables, and all guards and parades except on Saturdays and Sundays, but they may still attend to the interior economy of their troops or companies. Regimental Officers should attend the classes as often as possible.

The following course should be carried out as nearly as possible in the order given, regard being had to weather. About four hours' work each day should be exacted.

FIRST DAY.

Definitions.

Begin with a lecture describing the importance of reconnaissance in war, and how, by a proper division of labour, each man's work would form an important item of the reconnaissance. Then take the class out of doors, and instruct them thoroughly in the meaning of common military terms, with the details appertaining to them; such as—

Ground: Its various features.*
Water: Ditto.†
Roads: Different kinds and conditions.‡
Railways: Tunnels, viaducts, cuttings, embankments, sidings, &c.
Woods: Their details.§

comings as draftsmen by their greater power of observation and description.

* Open or close, undulating or level country, heights, valleys, ravines, cultivation, &c.

† Streams, rivers, nature of right or left bank, canals, streams for irrigation, current, banks; flashes, marshes, river sources, springs; bridges, fords, and water-mills (*see* page 83).

‡ Main roads, country roads, bridle paths, nature of route (whether metalled, how, and in what condition), tunnels; viaducts (their dimensions), gradients, boundaries, telegraphs (posts, stations, &c.) (*see* also page 74).

§ Forests, woods, groves, brushwood, or underwood, glades, rows of trees, &c. (*see* page 90).

Inhabited Places: Towns, villages, farms, &c.; walls, hedges, gardens, &c.; defensible houses, &c.

Special Features: Country houses, towers, tall chimneys, steeples, mills, lone trees, &c.

Each Non-commissioned Officer should carry with him a plate of conventional signs, and compare them with the actual features represented.

The Instructor must explain the likeness in each case.

N.B.—Throughout the course, questions on this first lesson should be frequently asked.

SECOND DAY.

Reading Maps.

Give a short lecture explaining the common errors made in depicting features of country.* Then take an ordinary map with military features not marked on it (a rough one might be prepared), and show how little of the necessary information it contains. Then show a six-inch map, with military features, and point out instances of the conventional signs which are by this time somewhat familiar. Question the Non-commissioned Officers on them. Then, placing the map before them, let each in turn suppose himself to start on the map from a point on a road or the open country, in a given direction, and tell what is passed over and what is on either side of the march.

Explain the chief points of the compass as seen on the map; but do not yet show the compass itself.

Question thoroughly till the class have fairly mastered the features of country, as shown on a map.

As a change during this lesson, they may pace distances for half an hour.†

* Common errors:—bridges, cuttings, embankments, trees, and houses too large; roads too wide; bends in roads exaggerated.

† As a rule, on level, even ground, infantry soldiers pace distances with fair regularity, if allowed to take the ordinary 'pace' of 30″. But it will be necessary to give frequent practice up and down hill, and over rough ground, and along winding roads.

THIRD AND FOURTH DAYS.

During these two days the Non-commissioned Officers should, at some convenient time, be taken out, if they are of cavalry or field artillery on horseback, if of infantry on foot; when each mounted Non-commissioned Officer should ascertain the pace of his horse at the walk and trot over a measured distance of not less than 200 yards; * after this the riders or men on foot should be sent at intervals over a distance of half a mile or so, reporting the distance as they estimate it on their return. The Instructor will of course know this distance accurately. Care must be taken that the Non-commissioned Officers do not compare their estimates. All distances to be estimated in yards.

During this practice those who are not actually pacing the distance may be questioned on features of ground within sight.

On these days the indoor work will be as follows:

Give out the plates of conventional signs to be copied, whenever there is spare time, with a hard black-lead pencil.

No attempt should be made at this stage to imitate the fineness of engraving, but there must be no possibility of mistake in the meaning of the work.

No printing must be attempted, but only clear small writing.

Also give the Non-commissioned Officers practice thus: Let each man have a piece of paper, marked in squares the sides of which represent known distances; the paper should also have two pencil lines on it representing a road. Write on the black board: 'At 100 yards road passes, by a brick bridge, over a stream which runs east to west, and is 20

* If your horse takes, say, 106 *steps* in going over 100 yards at a walk, you can turn any number of steps into the corresponding number of yards, by deducting 6 from every 100 steps taken. For example: 400 steps = (400 − 4 × 6) yards = 376 yards (nearly). And similarly for any other number of steps of the same horse moving at the same 'pace.' When pacing on horseback, count every other step, *i.e.* every time the off foot comes to the ground, and double the total.

yards wide. At 180 yards, cross lanes to ——— on east and ——— on west;' and so on, describing various features, which the men should mark at once on the paper, using black, red, green, and blue pencils, the red for buildings, green for woods, and blue for water.*

FIFTH DAY.

Explain the methods of copying, enlarging, and reducing maps, and give a piece of skeleton map, without hills, to be enlarged. Each man should start with a marked square, and add as many others grouped round it as he can do in the time. The map should represent a piece of country near at hand, and is to be enlarged to a scale of two inches to the mile.

SIXTH DAY.

Assemble in the class-room, and let each man provide himself with a rough scale, two inches to the mile, thus: On the edge of a piece of cardboard mark divisions of $\frac{1}{4}$ of an inch each. These will represent 220 yards. Divide the quarter inches into two parts. These subdivisions will then represent 110 yards each, a sufficient measure for rough purposes. The use of this, made in five minutes, will give the men ideas on the subject of scales. Go out on foot, carrying the skeleton maps prepared on the preceding day, and let the Non-commissioned Officers put in the features along the road by pacing, and estimating distances by the eye, always using the cardboard scale. By this time the Non-commissioned Officers will have discovered that they do not know exactly what features should be put in and reported. Tell them to write on the sketch whatever they think ought to be reported. They will encounter some difficulty, and be prepared for the lesson of the

* The common error in this practice is to draw everything too large, but it is well to accustom the men as soon as possible to draw on a small scale.

SEVENTH DAY.

Give a lecture on what is to be reported, and typical example of a good road sketch and report. Let the Non-commissioned Officers make fair copies of their sketches produced the day before, using black, red, green, and blue pencils.

Prepare another skeleton map for the next day, but of new ground.

EIGHTH DAY.

Precisely the same work as on the Sixth Day. The knowledge gained up to this time ought to ensure the production of a fairly good report. Cavalry Non-commissioned Officers should now be working on horseback.*

NINTH DAY.

Fair sketches and reports to be made from the work of the Eighth Day.

Give a lecture on slopes and practical methods of estimating them,† and on the representation of hills. Give

* Let the original drawing, done on horseback, be as neat and distinct as possible. Do not rest the sketching board upon the saddle or folded cloak, but hold it in your hand, or sling it from your neck. Use coloured pencils freely, and, when not in use, slip the pencil between the buttons of your jacket, or under the cloak strap. Use india-rubber, not the finger, to correct a mistake.

† The steepness of natural slopes of ground is much less than is usually imagined. Show the men examples on the ground of slopes of 2°, 5°, 12°, and 20°. When a hill sketch does not show clearly which is the bottom and which the top of a hill, draw a small arrow head, always pointing *down* hill.

Ground which rises 1 foot or 1 yard (measured vertically) in every 12 feet, or 12 yards (measured horizontally), is said to have a slope of '1 in 12,' or may be expressed thus '$\frac{1}{12}$'. This degree of steepness may be also expressed as '5 degrees,' or 5°, and similarly for other slopes.

Gradients may be found roughly as follows (Plate XI., *fig.* 5):

Let A B represent a man on horseback. B C the slope of the ground.

practice in the same, both in and out of doors. No time must be wasted in attempts at pretty drawings.*

TENTH DAY.

The same as during the latter part of the Ninth Day till some facility is acquired. Lend examples of hill shading to such as wish to practise out of hours, but no such example must be taken out of the class-room.

A fortnight will have elapsed between this and the first lesson, and already such of the Non-commissioned Officers as have fair capacity will have learnt enough to make a useful reconnaissance in any country, ordinary maps of which exist.

The second fortnight will be spent in sketching without maps, and in confirming the knowledge previously acquired.

C a point level with the man's eye (supposed to be 8′ above his horse's feet). The steepness of the slope may be found by measuring the distance B C.

If B C = 32	yards,	slope is	5	degrees,	or $\frac{1}{12}$.
,, = 21	,,	,,	,, 7	,,	,, $\frac{1}{8}$.
,, = 16	,,	,,	,, 10	,,	,, $\frac{1}{6}$.
,, = $10\frac{1}{2}$	,,	,,	,, 15	,,	,, $\frac{1}{4}$.
,, = 8	,,	,,	,, 20	,,	,, $\frac{1}{3}$.

If the observer be *on foot*, and his eye $5\frac{1}{2}$ feet above the ground—

If B C = 22	yards,	slope is	5	degrees,	or $\frac{1}{12}$.
,, = 15	,,	,,	,, 7	,,	,, $\frac{1}{8}$.
,, = 11	,,	,,	,, 10	,,	,, $\frac{1}{6}$
,, = $7\frac{1}{2}$	,,	,,	,, 15	,,	,, $\frac{1}{4}$
,, = $5\frac{1}{2}$	,,	,,	,, 20	,,	,, $\frac{1}{3}$

To find a point level with the eye when the observer is mounted.

Measure on a wall a height, A B (Plate XI., *fig.* 4), equal to height of observer's eye. Let the observer draw his sword, and hold it upright in such a position that the *point* is level with line C A; let him remember the exact position of his hand resting on his thigh. The method of applying this to practice in the field is obvious.

By this means any man may ascertain and report the most important gradients on roads or hill-sides.

* What is required is a clear drawing, sufficiently correct.

The lessons given during the past fortnight have been progressive, nothing being taught till the men have seen the want of it.

The same principle should be adopted for the rest of the course, which, however, cannot be laid down in detail, as so much must depend on the weather. No man can be expected to work well with compasses, &c., in cold and wet weather.

Non-commissioned Officers of cavalry should frequently make sketches on horseback.*

Third Week.

ELEVENTH DAY.

Supply each man with a pocket compass (which need not cost more than two or three shillings), a pencil and a piece of india-rubber, his scale, and the millboard and bands described above, and intended to act roughly as a sketching case ; even the cover of a book would do. There should be one sketching case for each class, and the Non-commissioned Officers should be taught to imitate it with rough materials, such as twine instead of straps, &c. Explain the use of the compass, and Magnetic North and South.† Take the class out to sketch a road in the rough-and-ready way suitable for war, as follows : Place the paper (fastened by elastic rings to the millboard) horizontally, with its longest sides parallel to the direction of the road. Draw a line to represent the direction of the road, and lay the compass on the paper near one of the top corners, as is most convenient. Mark on the paper, without altering its position, points opposite the two ends of the needle, and draw a line to represent the Magnetic North and South. Then pace along the road, putting in the features as

* Although some experienced practical men say that the reconnoitrer should dismount when he has to make a sketch, yet in many cases a very fair sketch may be made on horseback—and men should learn, if possible, how to do this.

† Sketches sent in by Non-commissioned Officers need only show the Magnetic North, and not the True North (*see* page 4).

you go until you come to the first bend. There, place the compass again on the paper, adjusting the *paper* until magnetic North and South line, as previously marked upon it, correspond in direction with the ends of the needle. Draw by eye a line in the new direction of the road, and proceed as before.

TWELFTH, THIRTEENTH, FOURTEENTH, AND FIFTEENTH DAYS.

Give constant practice in sketching with common compass on a scale of two inches to a mile, and in making reports of roads, rivers, &c. The Instructor must invariably be present, and teach the men to save time by working in pairs. He should point out good positions for troops and all things that ought to be reported on. Hills must only be represented (as they would be in war) by * vertical hachures rapidly done, but their height should be calculated and marked. During this week the principles of contouring may be taught; but no time should be lost in contouring accurately, as the object is not to make maps but practical sketches: calculations of heights and distances by simple methods must be taught.

Fourth Week.

Teach the use of the prismatic compass and protractor to all who show aptitude, and continue sketching ground and making reports. The best pupils may be taught the use of check angles and interpolation. Sufficient horizontal hachuring may be practised indoors to detect any talent for it; but the principle must be acted upon that these Non-commissioned Officers are not to be trained as map makers, but as practical reconnoitrers of ground. Part of this week must be employed in testing the acquirements of the Non-commissioned Officers.

N.B.—During the whole of the course, frequently remind

* Approximate contours and stumping have now been adopted for this purpose (*see* page 56).

the men that the work they are about may often have to be done in the neighbourhood of the enemy, and that in all their thoughts the idea of an existing enemy must have place.*

Though a course occupying a month has been laid down for guidance, the Instructor will probably be able to judge at the end of the second week whether all the Non-commissioned Officers will receive benefit from further teaching. If, in any case, it appears that no benefit would accrue to the Service from instruction during the third and fourth weeks, the Non-commissioned Officer should be sent back to regimental duty.

On the other hand, such Non-commissioned Officers as show exceptional ability should be encouraged to carry the subject further and qualify themselves to become Instructors in their regiments.† Examination in their power of instructing should form one of the tests used during the last week.

During the latter part of the course cavalry Non-commissioned Officers and mounted Non-commissioned Officers of artillery should practise reconnoitring over a wider extent of ground than is possible for infantry in the same time, and cavalry and infantry together should, once or twice, be worked together, if the class is mixed, or if the proximity of classes of different arms admits of combined work; the cavalry taking the distant portions of the ground to be reconnoitred, the infantry that close to the march. It must, however, be understood that the length of the course is only sufficient to allow of the acquisition of elementary knowledge.

* To carry out this idea, the Instructor should mention in what direction the enemy is supposed to be, especially when road sketching is practised—the men being taught how to approach a hill or other cover in order to reconnoitre it, if an enemy were near. This part of the instruction gives great scope for useful work.

† These men might be instructed in 'Eye Sketching' without instruments. Paper ruled into small squares should be used (*see* note *, page 74). The bends of the roads, &c., and distances are put in by eye aided by the small squares (*see* also pages 66–67).

The application of such knowledge must be practised assiduously afterwards with special reference to the capabilities and uses of the arm, whether infantry, cavalry, or artillery.

The following typical examples for practising Non-commissioned Officers in reconnaissance may be found useful. Some of these may be carried out at almost every station, and they will serve to show the men the practical utility of the foregoing course :

1. Find out how many men and horses might be billeted in the hamlet of ——— (*see* page 107) in time of war—showing by sketch where each man and horse would be lodged, with sufficient clearness to guide the officer in charge of a detachment to tell off the men to their billets immediately on arrival.

2. Examine the country between A, B, and C, and ascertain how a patrol of 4 men might move from D to E, and thence to F without being seen from G.

Select the shortest practicable route that fulfils these conditions and mark it on the sketch, or describe it in writing.

3. What point, not more than $\frac{1}{4}$ of a mile from the road between A and B, gives the best view of the country towards the north-west.

4. Mark on a map the line, always in sight of some part of the road A B, from which the best view may be had of the country towards the west. (A useful thing for 'flanking party' to know when enemy is towards the west.)

5. In charge of a 'detached party' on outpost duty watching the ground between A, B, C, D, send in sketch or written report of this portion of ground (*see* page 102).

6. A mounted orderly is sent from A with a letter to be delivered at B as soon as possible. Mark best route to follow ; the bridge at C is supposed to be destroyed, the hill (wood, village, &c.) at D being in the enemy's hands. You are provided with a map, scale 1″ to 1 mile.

7. Describe the road between A and B so far as you can examine it without leaving the ground included between C, D, E, and F.

8. Starting from B you are ordered to reconnoitre the valley east of ridge A, unseen by the enemy, whose vedettes are at C, D, E, and F. Mark on sketch the route you would follow.

9. Four squadrons of cavalry are to be watered in village of ——— in the shortest time practicable. Examine the village and report how the process of watering can best be carried out—describing where water is to be found, whether in ponds, wells, &c., and what number of horses should go to each place, and by what route—to and from.

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Fig 1.

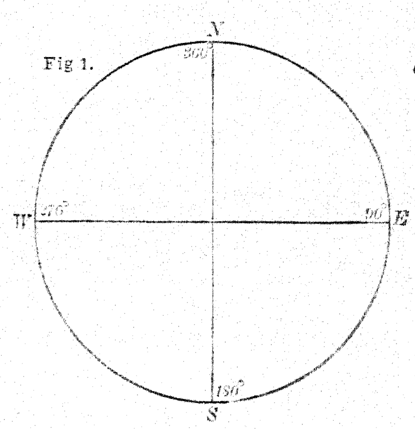


Fig.2.

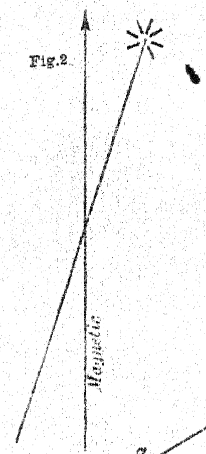


Fig.3

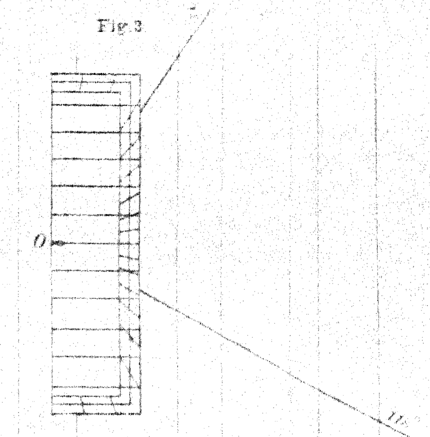


Fig.4.

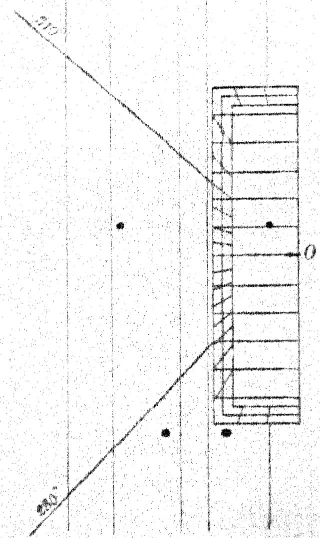


Fig.5.

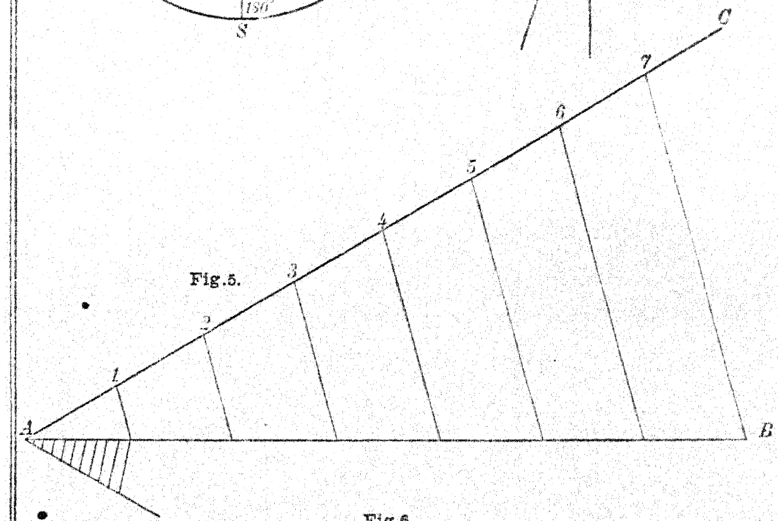
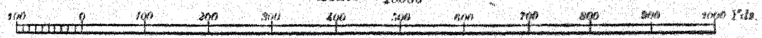


Fig.6.

Scale $\frac{1}{10560}$



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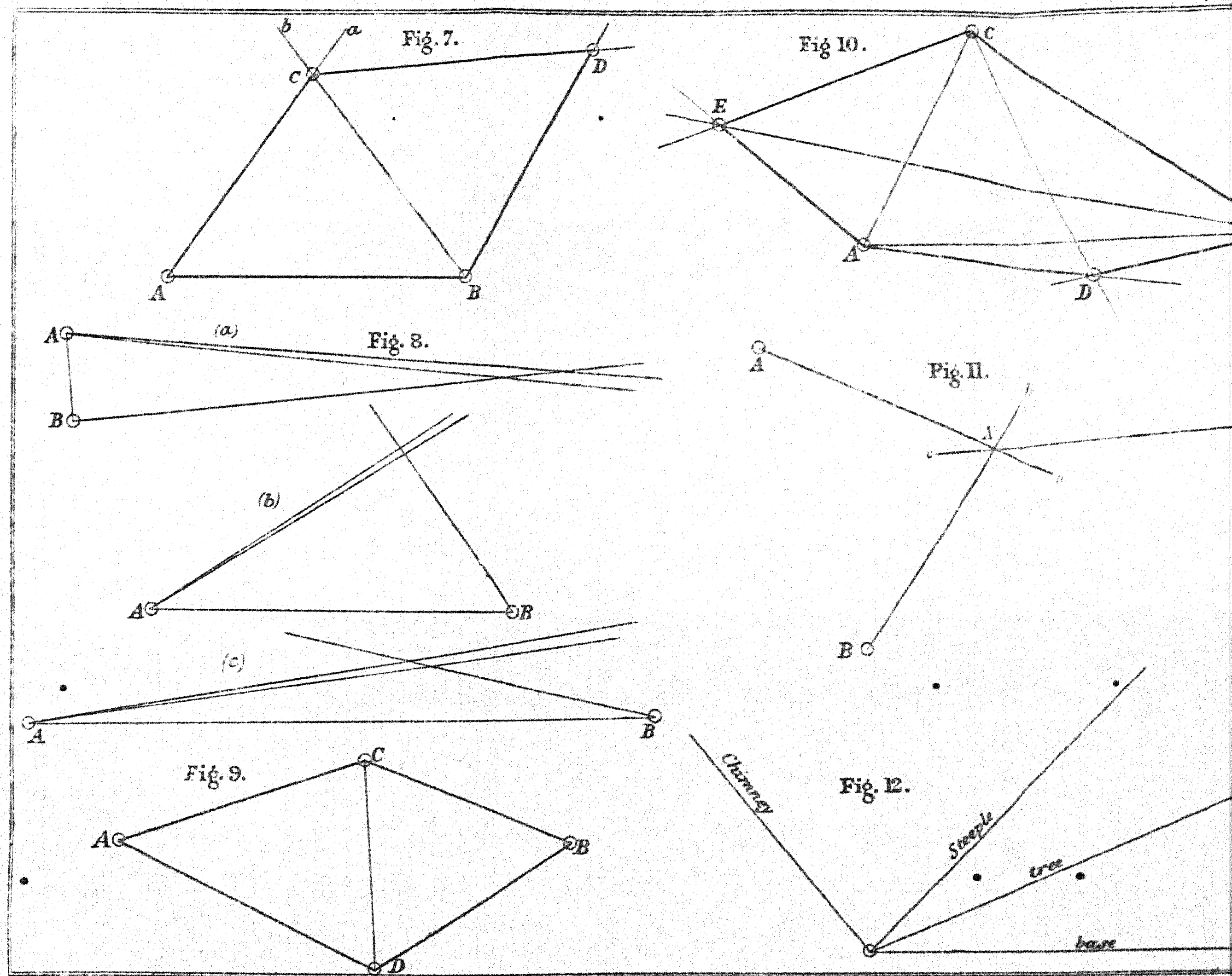
Fig. 7.
b
a
C
D
A
B
Fig 10.
C
E
A
D
A
B
(a)
Fig. 8.
(b)
A
B
(c)
A
B
Fig. 11.
A
B
Fig. 9.
C
A
B
D
Chimney
Fig. 12.
Steeple
tree
base

PLATE III.

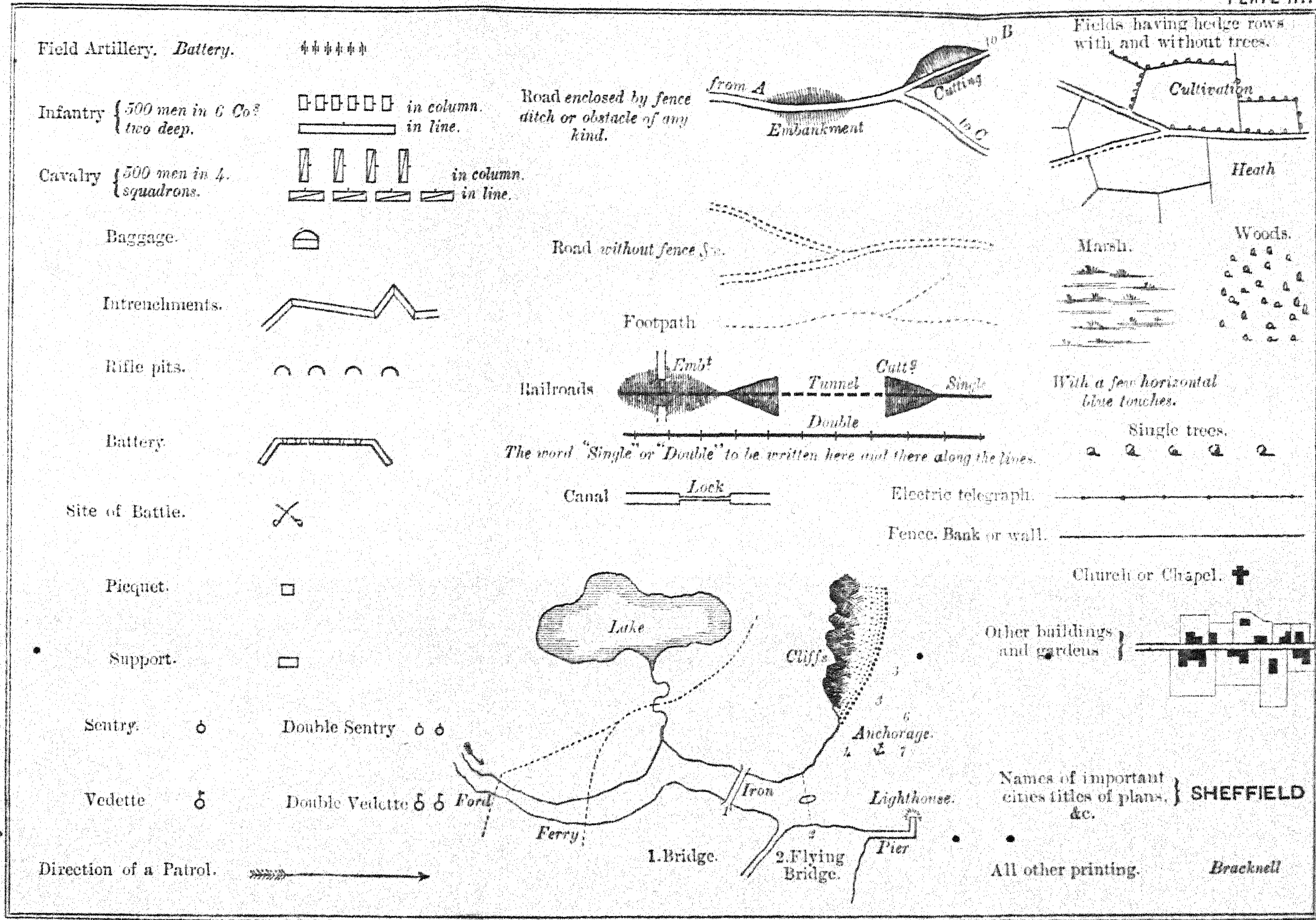
Field Artillery. Battery.
Infantry 500 men in 6 Co.s two deep.
in column.
in line.
Cavalry 500 men in 4. squadrons.
in column.
in line.
Baggage.
Intrenchments.
Rifle pits.
Battery.
Site of Battle.
Picquet.
Support.
Sentry.
Double Sentry
Vedette
Double Vedette
Direction of a Patrol.
Road enclosed by fence ditch or obstacle of any kind.
from A
to B
Cutting
to C
Embankment
Road without fence &c.
Footpath
Railroads
Embt
Tunnel
Cutt.g
Single
Double
The word "Single" or "Double" to be written here and there along the lines.
Canal
Lock
Lake
Cliffs
Anchorage.
Ford
Ferry
Iron
Lighthouse.
Pier
1.Bridge.
2.Flying Bridge.
Fields having hedge rows with and without trees.
Cultivation
Heath
Marsh.
Woods.
With a few horizontal blue touches.
Single trees.
Electric telegraph.
Fence, Bank or wall.
Church or Chapel.
Other buildings and gardens
Names of important cities titles of plans, &c.
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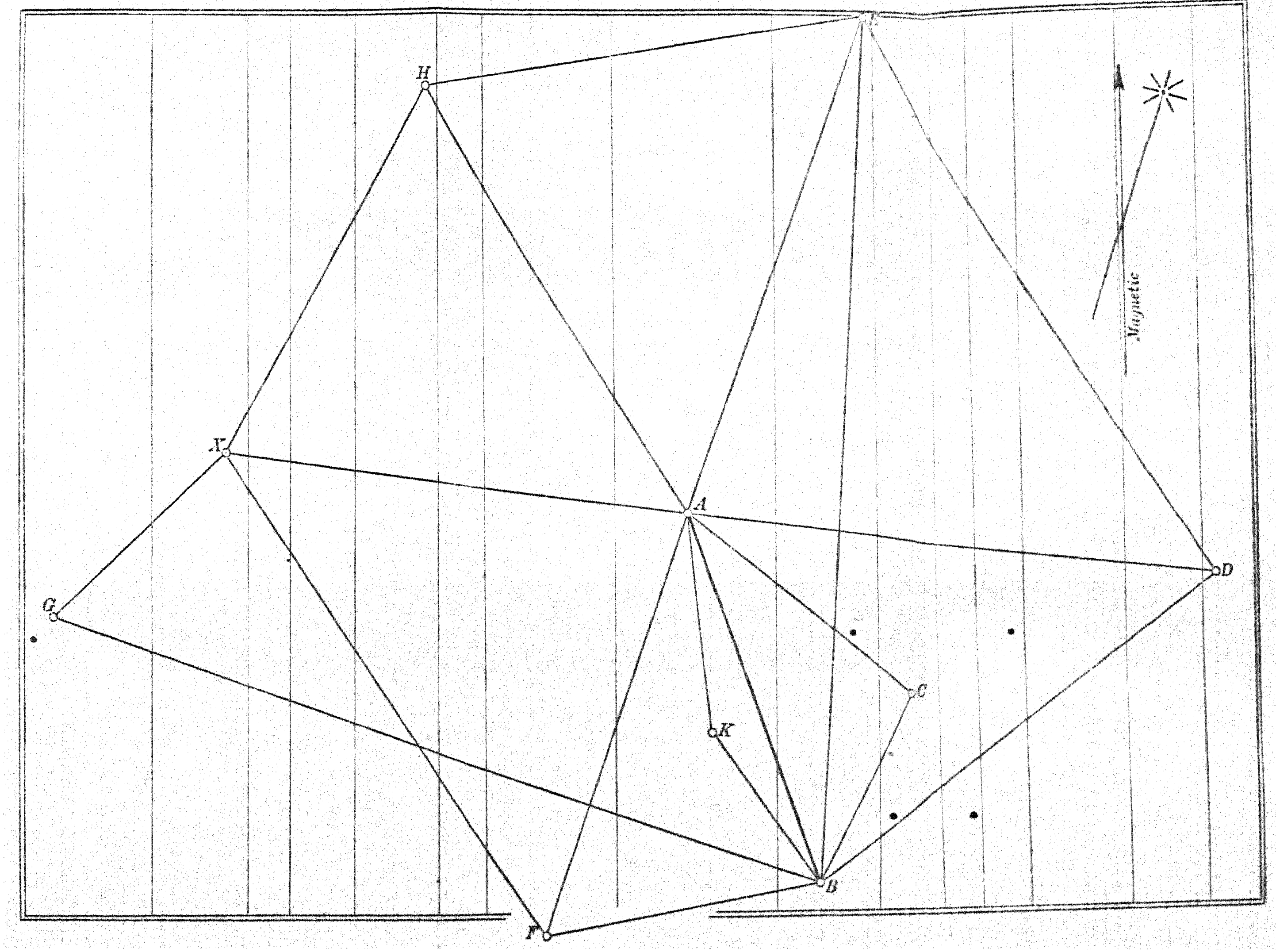
PLATE IV.



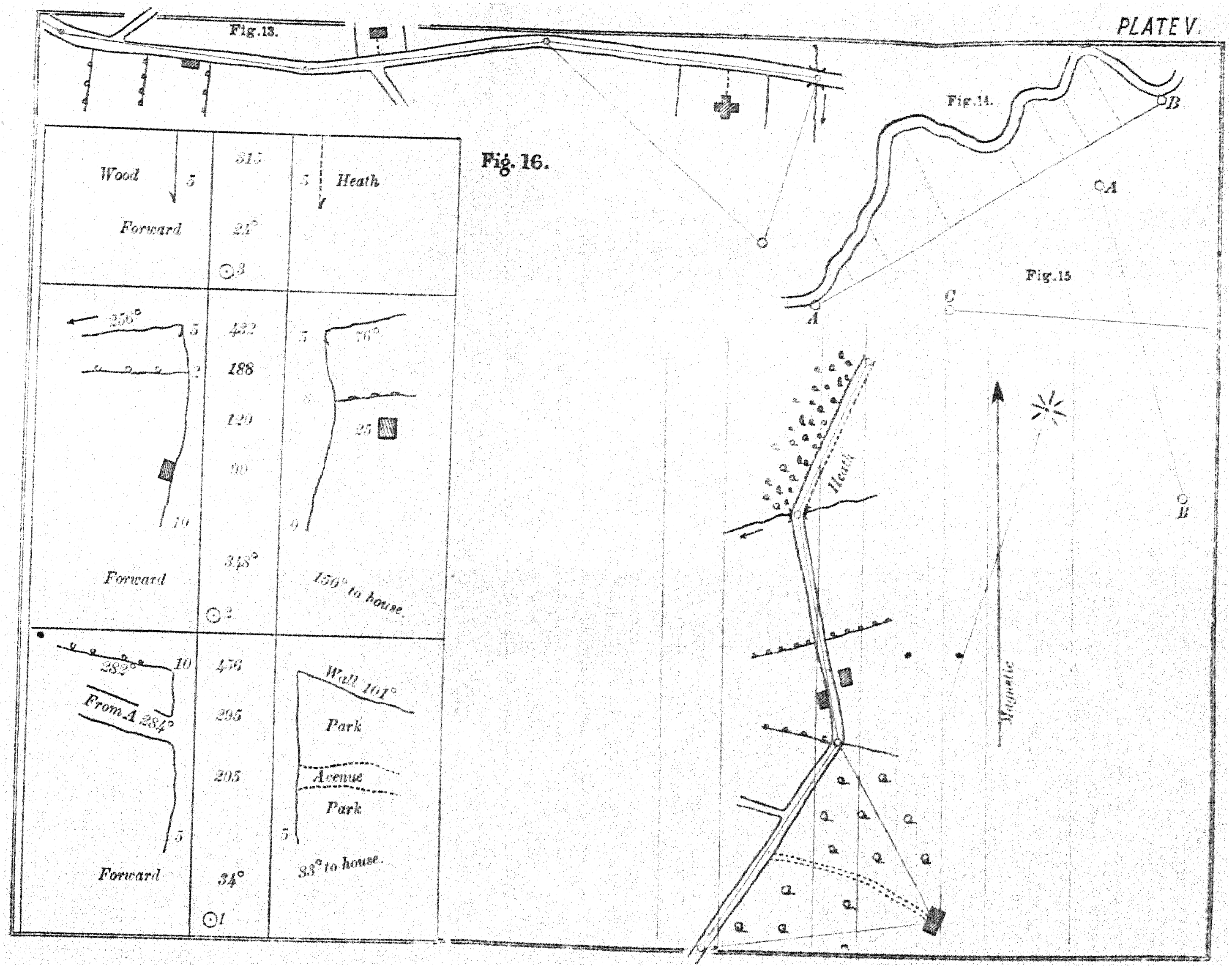


Fig. 13.
Fig. 14.
A
B
Fig. 15.
C
A
B
Fig. 16.
Wood
Heath
Forward
315
24°
3
256°
432
188
120
90
76°
25
348°
Forward
150° to house.
2
282°
From A 284°
456
295
205
Wall 101°
Park
Avenue
Park
Forward
34°
83° to house.
1
Heath
Magnetic

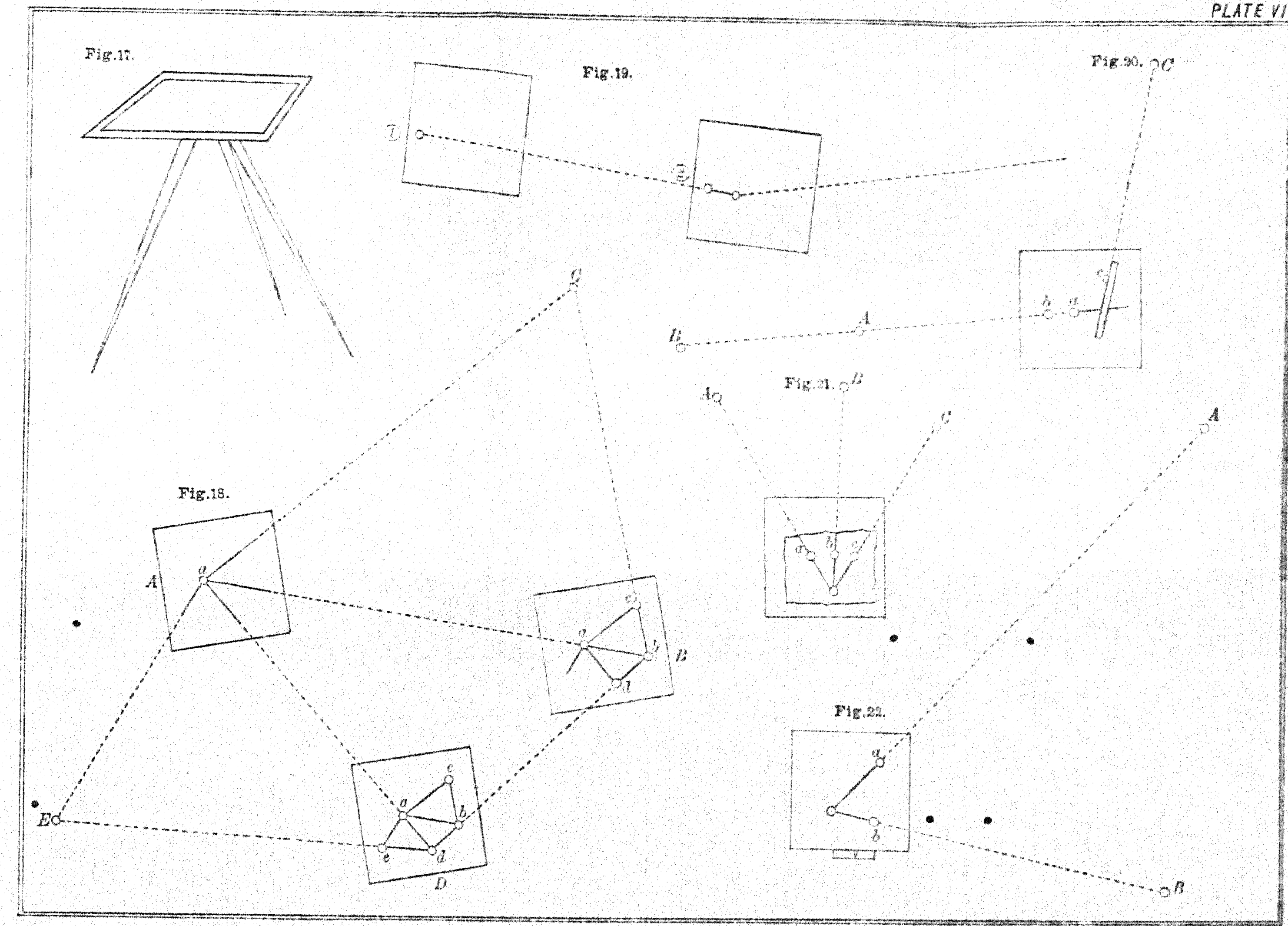
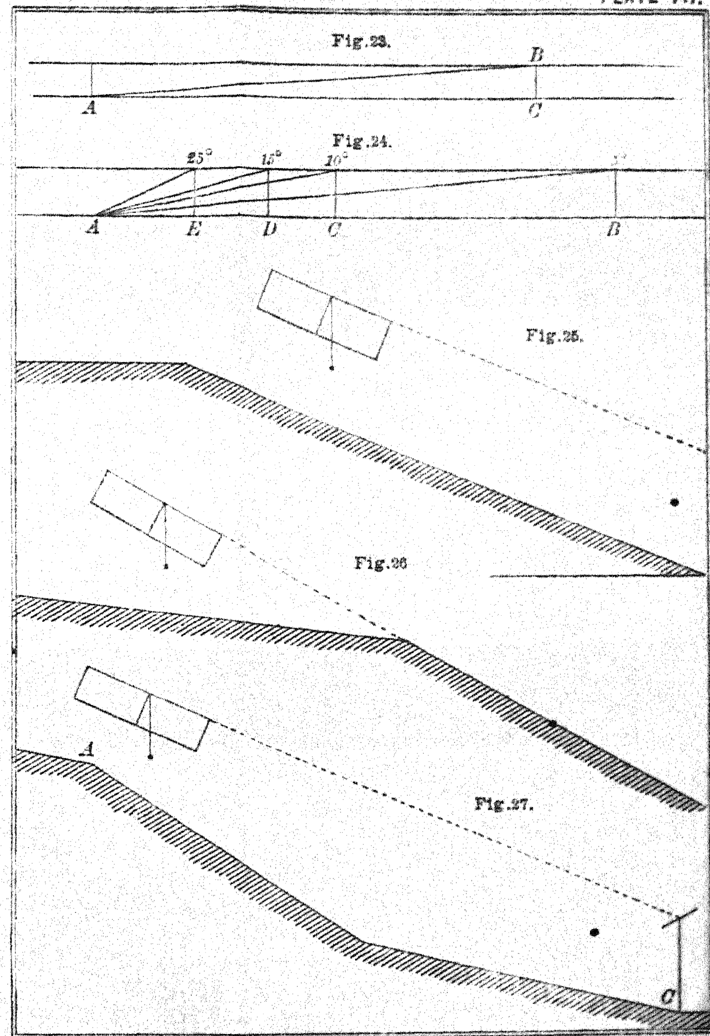


Fig.17.
Fig.18.
Fig.19.
Fig.20.
Fig.21.
Fig.22.
A
B
C
D
E
a
b
c
d
e

PLATE VII.



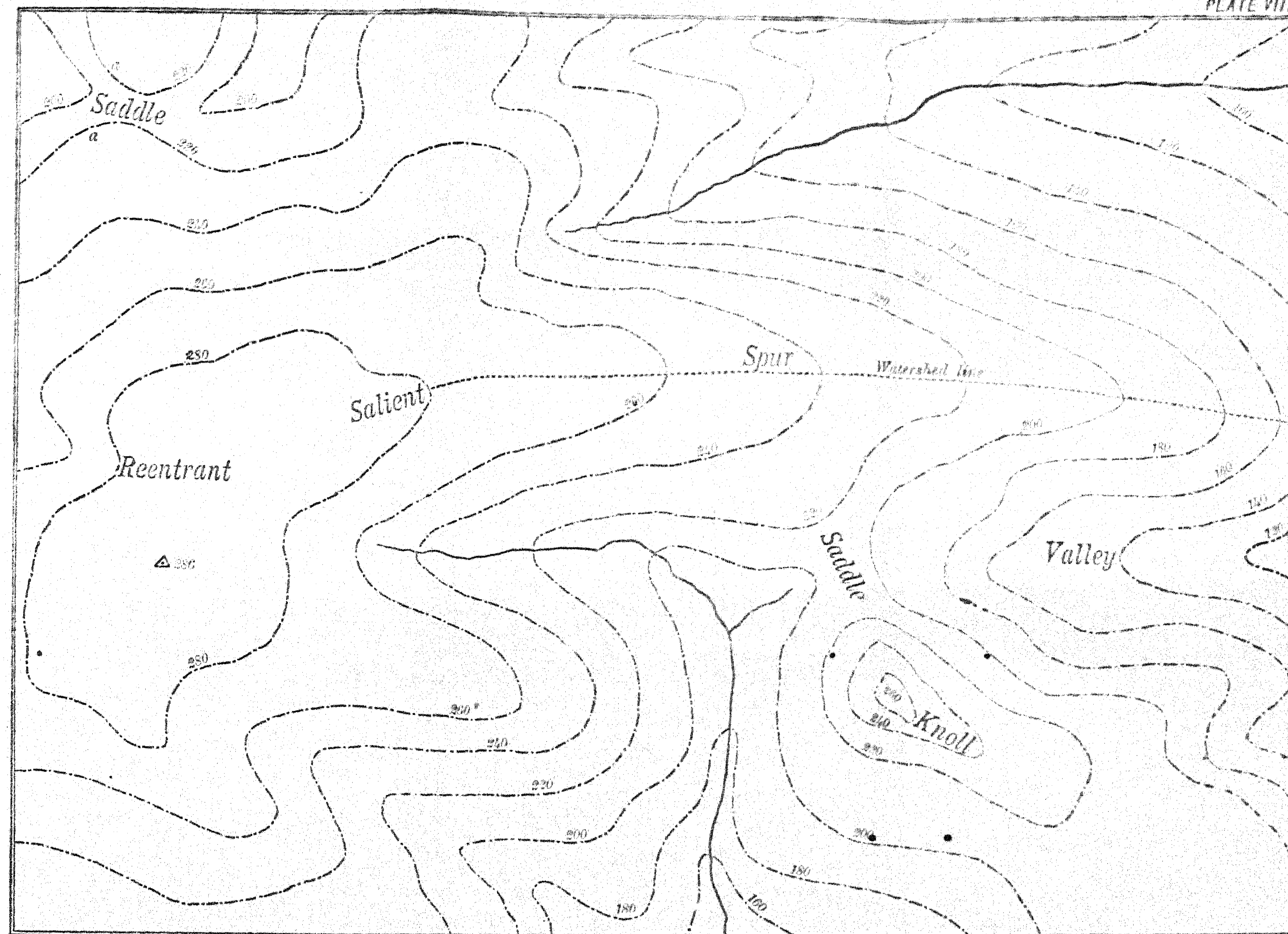

Saddle
a
Spur
Watershed line
Salient
Reentrant
Saddle
Valley
Knoll
240
260
280
220
200
180
160

PLATE IX.

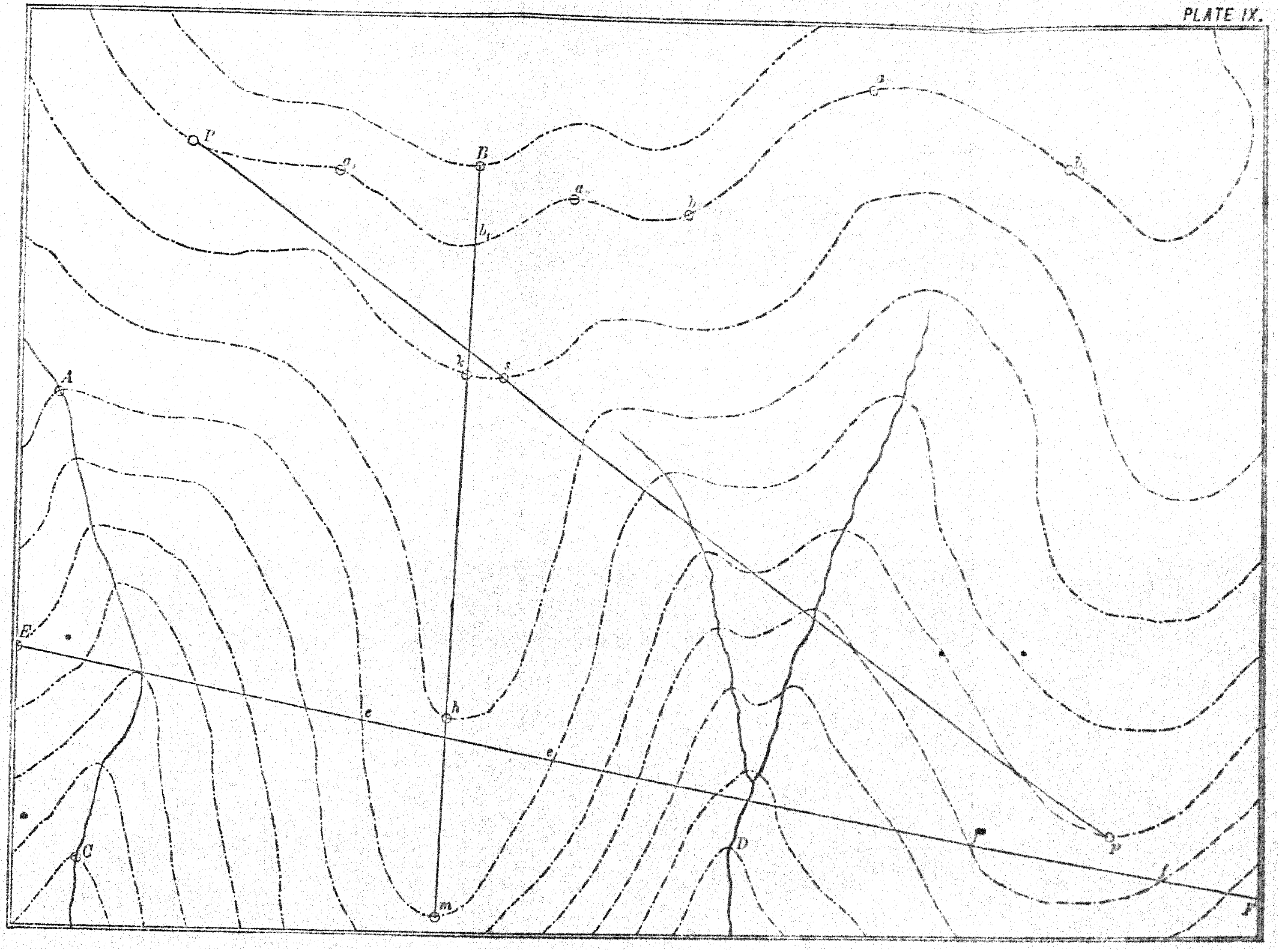
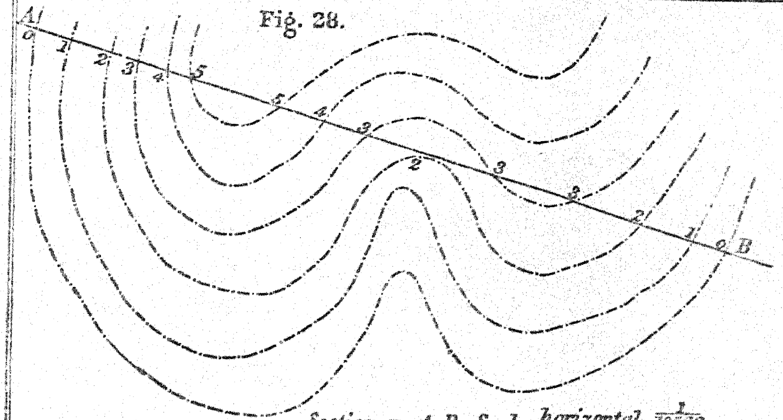


PLATE X.

Fig. 28.



Section on A. B. Scale horizontal $\frac{1}{10560}$ vertical $\frac{1}{3520}$

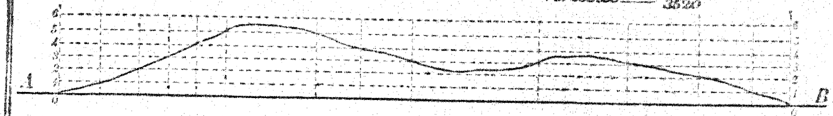
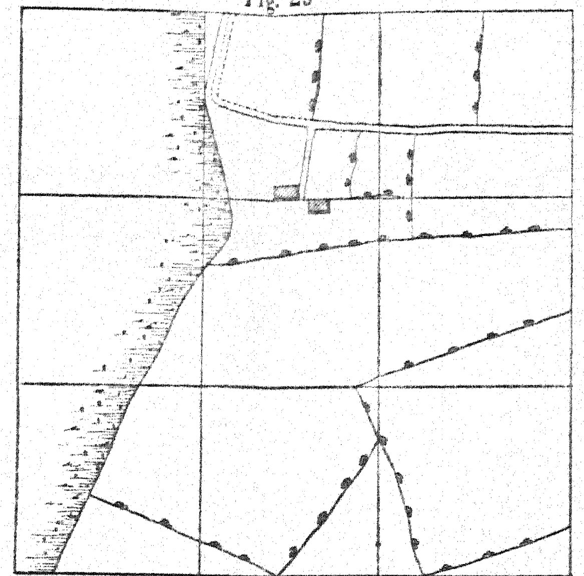


Fig. 29



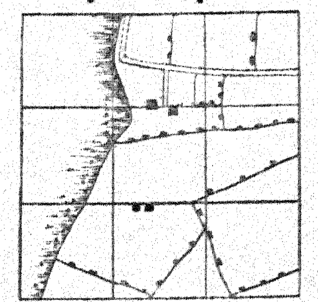
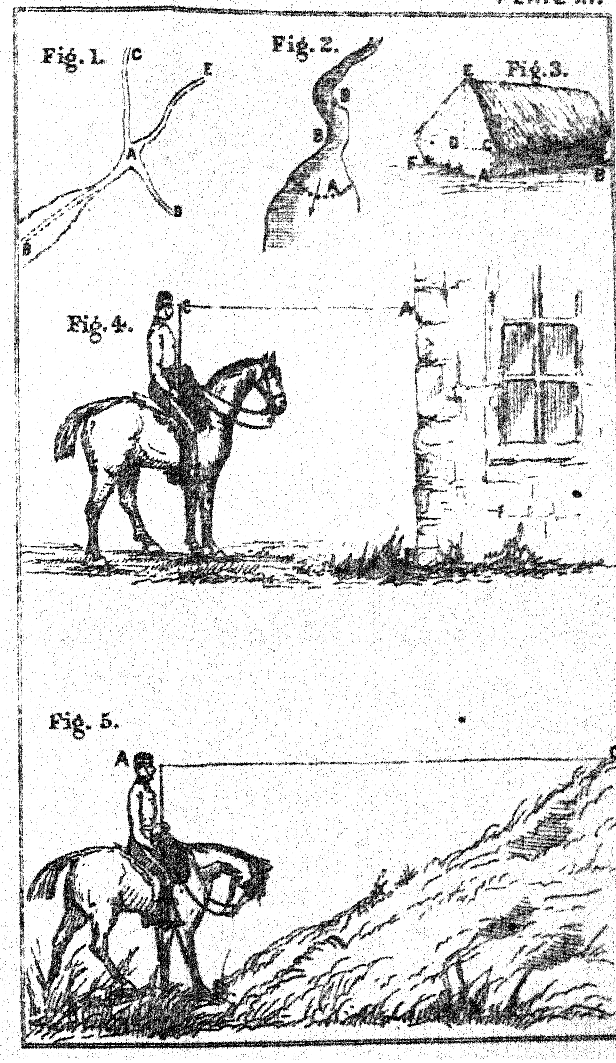
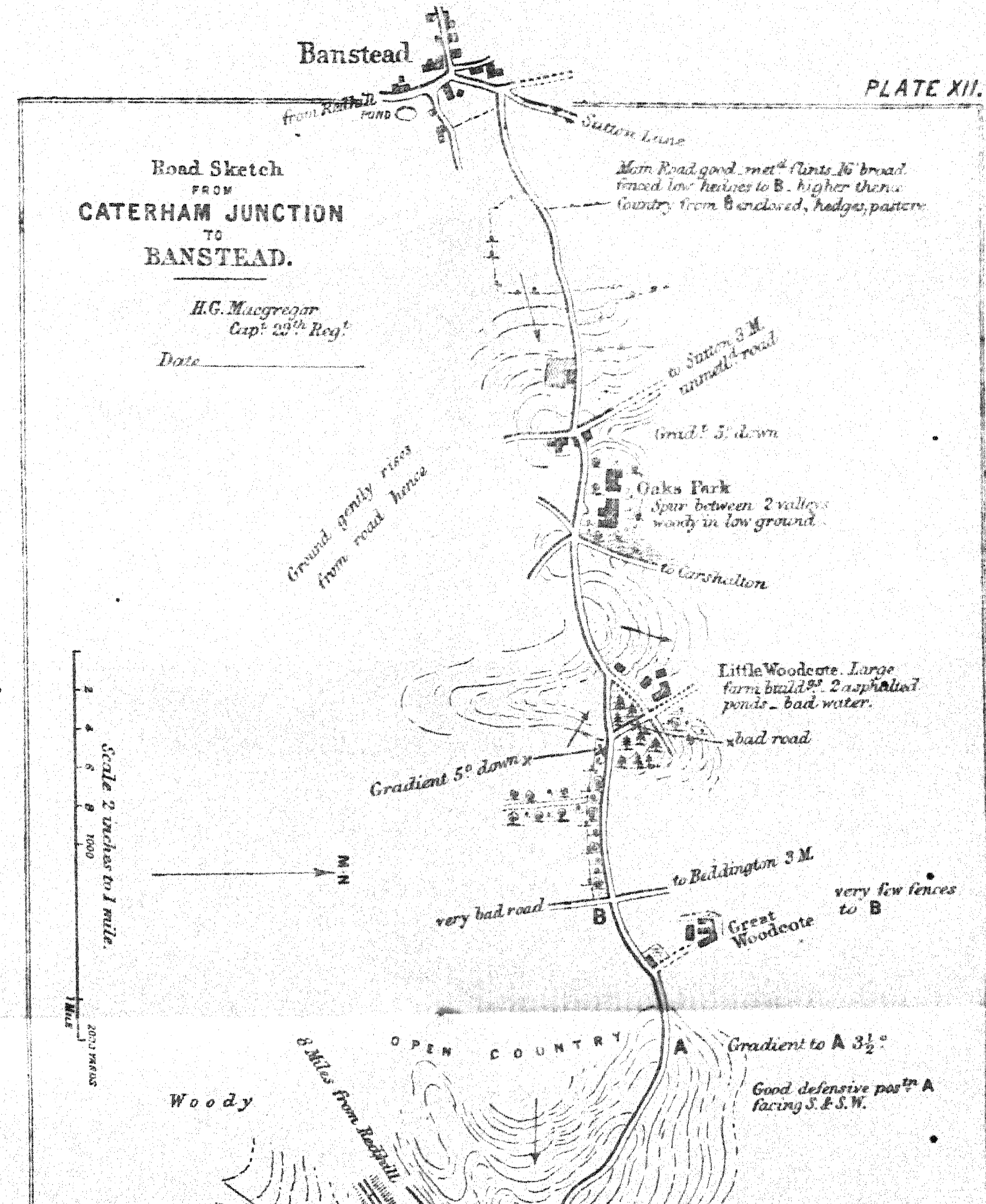
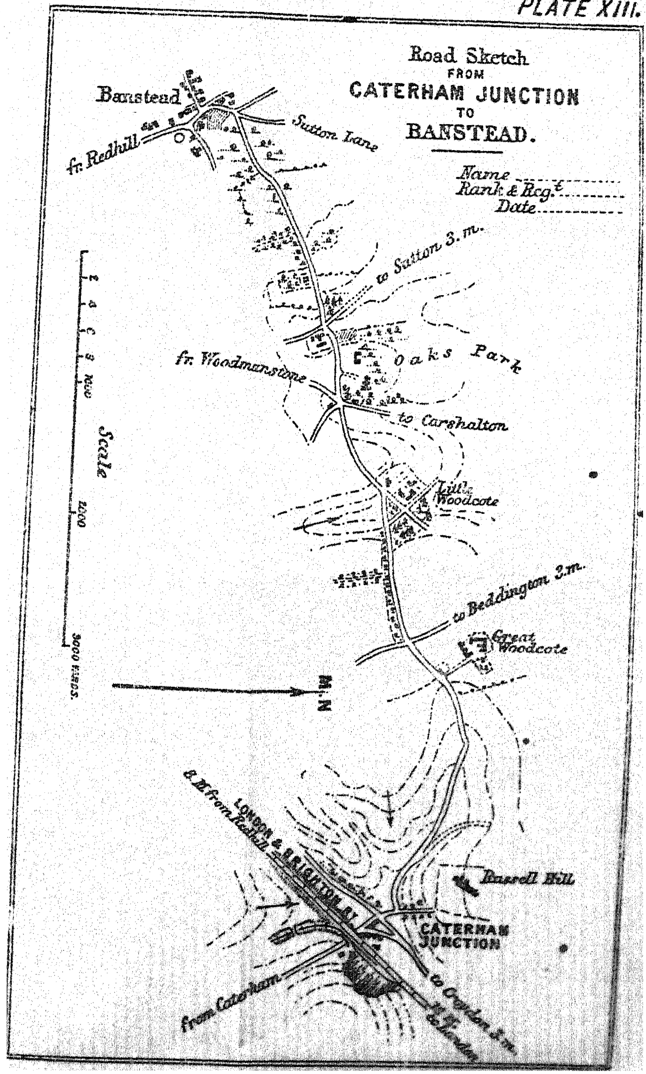
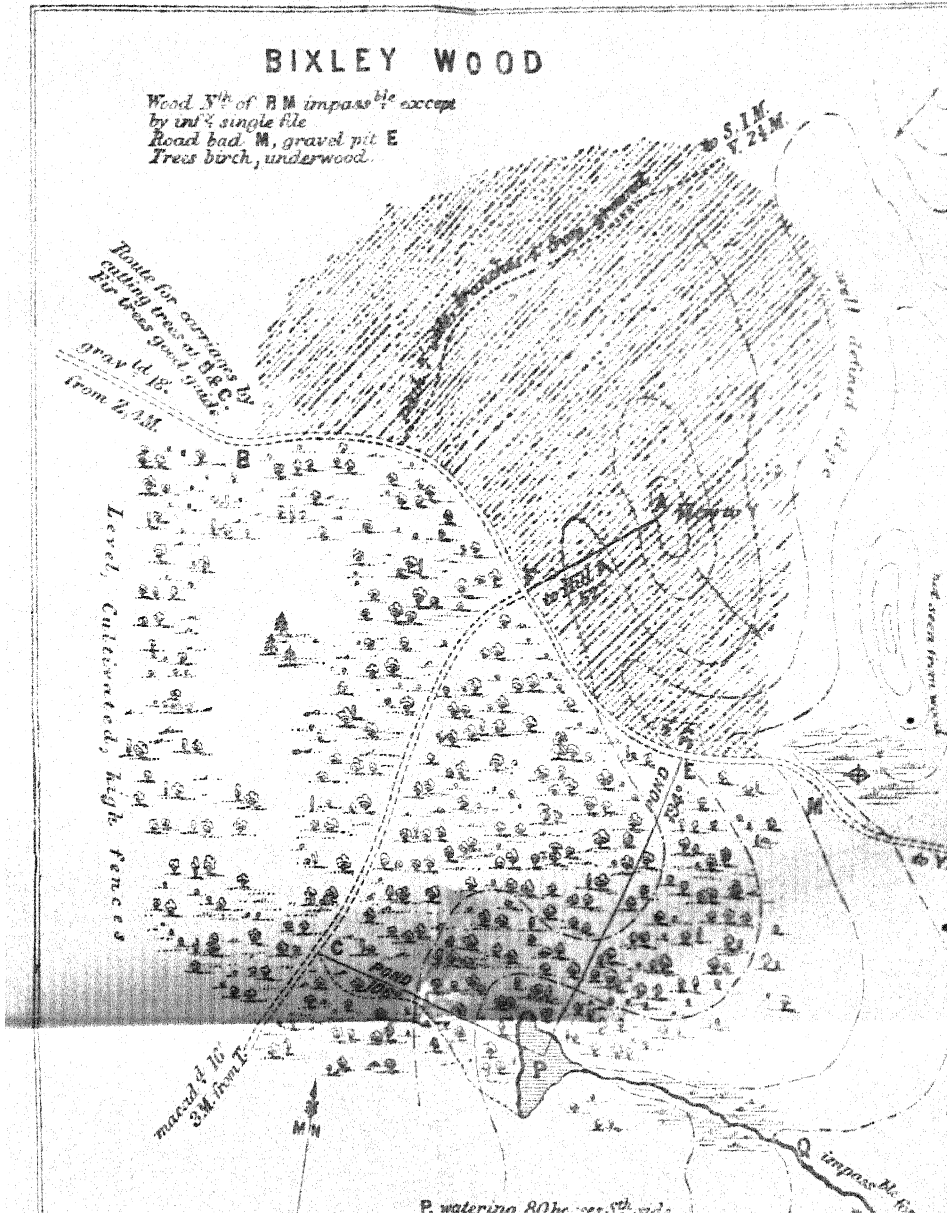


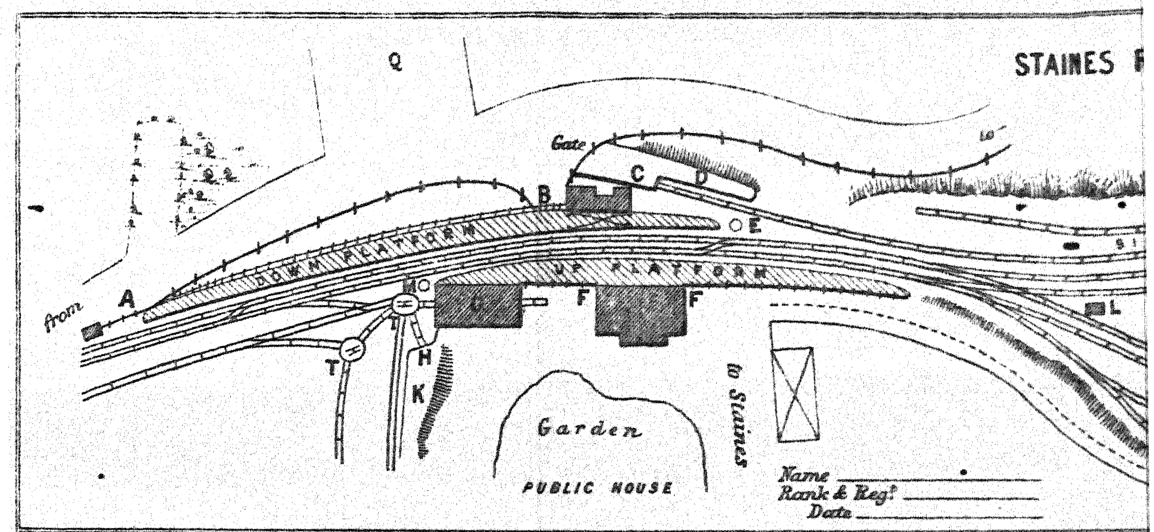
PLATE XI.




Road Sketch
FROM
CATERHAM JUNCTION
TO
BANSTEAD.
H.G. Macgregor
Capt. 29th Regt.
Date
Banstead
from Redhill
POND
Sutton Lane
Main Road good, metd. flints 16' broad
fenced low hedges to B. higher thence
Country from B enclosed, hedges, pasture
to Sutton 3 M.
unmetld. road
Gradt. 5° down
Oaks Park
Spur between 2 valleys
woody in low ground
Ground gently rises
from road hence
to Carshalton
Little Woodcote. Large
farm buildgs. 2 asphalted
ponds - bad water.
bad road
Gradient 5° down
Scale 2 inches to 1 mile.
2000 YARDS
1 MILE
M.N.
to Beddington 3 M.
very bad road
B
very few fences
to B
Great
Woodcote
OPEN COUNTRY
A
Gradient to A 3½°
Good defensive posn. A
facing S. & S.W.
Woody
8 Miles from Redhill


Road Sketch
FROM
CATERHAM JUNCTION
TO
BANSTEAD.
Name
Rank & Regt.
Date
Banstead
fr. Redhill
Sutton Lane
to Sutton 3. m.
Oaks Park
fr. Woodmanstone
to Carshalton
Little Woodcote
to Beddington 3.m.
Great Woodcote
Russell Hill
CATERHAM JUNCTION
LONDON & BRIGHTON RY.
B. M. from Redhill
from Caterham
to Croydon 3 m.
Scale
2000
3000 YARDS.
M. N


BIXLEY WOOD
Wood Nth of B M impassble except
by intry single file
Road bad M, gravel pit E
Trees birch, underwood.
Route for carriages by
cutting trees at B & C.
Fir trees good guide
gravl rd 18.
from Z, 4 M.
Level, Cultivated, high fences
to Hill A
to S. I. M.
V. 2½ M.
well defined edge
POND
POND
E
B
C
P
M
Q
macad rd 16.
3 M. from T.
M N
P. watering 80 horses
impass



STAINES
Q
Gate
A
B
C
D
E
F
F
H
K
T
L
DOWN PLATFORM
UP PLATFORM
from
to Staines
Garden
PUBLIC HOUSE
Name
Rank & Regt
Date

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